A Study On Clinical and Laboratory Parameters in Diagnosing Patients with Acute Appendicitis

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CERTIFICATE

Certified that this is the bonafide dissertation done by Dr. VIJAY KANNAN. S and submitted in partial fulfillment of the requirement for the award of M.S. Degree in GENERAL SURGERY (Branch I) of The Tamilnadu Dr. M. G. R. Medical University, Chennai.

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DECLARATION

I solemnly declare that the dissertation titled "**A STUDY ON CLINICAL AND LABORATORY PARAMETERS IN DIAGNOSING PATIENTS WITH ACUTE APPENDICITIS"** was done by me from September 2011 to August 2012 under the guidance and supervision of **Prof .Dr. P.V.VASANTHA KUMAR, M.S.**

This dissertation is submitted to the Tamilnadu Dr. M. G. R. Medical university towards the partial fulfillment of the requirement for the award of M.S. Degree in General Surgery (Branch I)

Place: Dr. VIJAY KANNAN. S

Date:

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CONTENTS

INTRODUCTION

Acute appendicitis is one of the more common surgical emergencies with a lifetime prevalence rate of one in seven. The diagnosis of acute appendicitis is purely based on history and clinical examination combined with laboratory investigations such as white blood cell count. However due to variation in clinical presentation and findings making a correct diagnosis of appendicitis is challenging. This leads on to missed diagnosis in about of 20% of patients initially and a negative appendicectomy rate of 14 – 40 %. A delay in diagnosis and subsequent treatment leads on to appendicular perforation and a significant increase in morbidity and mortality. The surgeon's goals are to evaluate patients referred for suspected appendicitis and to minimize the negative appendectomy rate without increasing the incidence of perforation.

Various scoring systems have been suggested in different parts which help to diagnose a case of acute appendicitis. Of these Alvarado and modified Alvarado scoring systems are the two most commonly used scoring systems. But these scoring systems were developed for the western population and they lack sensitivity and specificity when used for our population. Other scoring systems mentioned in literature are the IRA Teicher's, Fenoy's and Ohmanns scoring system. A new scoring system named RIPASA scoring system has been developed which is more applicable for the south asian population.

The laboratory investigations namely white blood cell count (WBC), C-reactive protein (CRP) and erythrocyte blood sedimentation rate (ESR) are useful in diagnosing acute appendicitis. But for the diagnosis of perforated appendicitis there is no laboratory investigation that can be used as a marker. Until recently it is stated that perforated appendicitis has been associated with hyperbilirubinaemia.

This study proposes to compare the various scoring systems in diagnosing a case of acute appendicitis and to suggest a scoring system which is suitable for our population. This study also intends identify any markers for the preoperative diagnosis of appendiceal perforation.

AIMS OF THE STUDY

1. To compare the sensitivity, specificity, positive predictive value and negative predictive value of various scoring systems namely, Alvarado, Modified Alvarado scoring system (MASS), Teicher, Fenoy, Ohmann and RIPASA scoring system.

2. To propose and suggest a new scoring system which is more suitable for our population and compare it with other scoring systems.

3. To identify an appropriate marker for the preoperative diagnosis of appendicular perforation.

MATERIALS AND METHODS

Study area:

Coimbatore Medical College Hospital (CMCH), Coimbatore

Study Population:

Patients admitted in CMCH with symptoms suggestive of acute appendicitis and taken up for appendicectomy.

Inclusion criteria:

1. Patients scheduled for appendectomies for acute appendicitis at the emergency unit of our institution.
2. Patients older than 12 years of age.

Exclusion criteria:

1. Patients younger than 12 years of age
2. A documented history of viral hepatitis, chronic liver disease and haemolytic diseases.
3. Patients preoperatively diagnosed as appendicular abscess.
4. Pregnant women.

Study period:

12 months (September 2011 to August 2012).

Sample size:

All patients eligible by inclusion and exclusion criteria are to be included in the study.

Study design:

A cross sectional observational study is to be conducted on patients admitted in CMCH for appendicectomy. Informed consent will be taken from each respondent.

Study tools:

Scoring Systems to be used are pre tested Alvarado scoring system, Modified Alvarado scoring system (MASS), Teicher's score, Fenoy's score, Ohmanns scoring system and RIPASA scoring system.

Parameters to be studied:

Specific Parameters to be measured for objectives 1 and 2:

Preformed Performa which includes the demographic profile of each patient, history pain, fever, nausea, vomiting, dysuria and anorexia, clinical examination findings such as RIF tenderness, guarding, rigidity, rebound

tenderness, Rousing sign and elevated temperature. Laboratory investigations such as WBC total count & differential count, CRP, Urine analysis are to be done.

The per-operative macroscopic appearance of the appendix specimen and subsequent histo-pathological study of the specimen is to be performed.

Specific Parameters to be measured for objective 3:

The per-operative macroscopic appearance of the appendix specimen will be noted. Laboratory investigations such as Liver function tests, CRP estimation, WBC counts are to be measured.

Plan for analysis of data:

Data is to be analyzed using the statistical package SPSS 16. Chi-square tests, Student's *t* tests, significance testing, and 95% Confidence Interval formulation are to be carried out wherever appropriate.

Review of Literature

History:

In 1735, Claudius Amyand, military surgeon, performed the first reported appendectomy for a perforated appendix with a stercoral fistula[1]

In 1880, Lawson Tait performed the first appendectomy for appendicitis by a correct preoperative diagnosis[2].

In 1886, Reginald Fitz of Boston coined the term *appendicitis* and identified the appendix as the primary cause of right lower quadrant inflammation. He recommended early surgical treatment of the disease.

Richard Hall reported the first survival of a patient after removal of a perforated appendix.

In 1889, Chester McBurney described characteristic migratory pain as well as localization of the pain along an oblique line from the anterior superior iliac spine to the umbilicus[3].

In 1894, McBurney described a right lower quadrant muscle-splitting incision for removal of the appendix[3]

In 1983, Kurt Semm, a gynecologist, performed the first laparoscopic appendectomy for a non-inflamed appendix[4].

In 1987, Schreiber performed a laparoscopic assisted appendectomy for the treatment of acute appendicitis[5].

Appendicitis:

Acute appendicitis is one of the most common general surgical emergency that has a lifetime risk of about 7 %[6]. The peak age of incidence is from 10 years to 30 years[6]. The diagnosis of acute appendicitis has been made by history and physical examination for more than a century now. The incidence of acute appendicitis has fallen dramatically nowadays and the individual lifetime risk of appendicectomy is 8.6% and 6.7% among males and females respectively[7].

In recent years, the incidence of the disease and mortality have been on a downward trend in developed countries, presumably because of earlier diagnosis, increasing public awareness, effective antibiotics and early surgery. The situation in the developing world is the opposite with some workers noting a rise in the incidence of appendicitis, presumably because the diet in these parts of the world is today resembling more and more that of the West. The incidence of perforation has remained the same.

The disease is commonest in the second and third decades of life and rare in the under twos and the elderly although in the latter age groups the complication rates are higher[7]. Males are more affected than females and the disease is commoner in individuals of higher social status.

Acute appendicitis was relatively unknown before the 19th century. Following a change in diet from cellulose based foodstuffs to foods rich in meat; its meteoric rise to become the most important abdominal disease was phenomenal. But, the

diet factor could not explain everything. The fact that the disease could affect vegetarians and infants as well begged for other explanations for the rise.

Aetiological theories

Lack of fibre theory:

Proposed early in the century when the disease was relatively new as a distinct entity. It received a boost in the 1970's as the disease was noted to be rare among the rural populations of developing nations. Today the theory is shaky as the falling incidence of the disease started from the 1930's while fibre intake increased only recently. In addition, the disease is still rare among urban blacks despite their low fibre intake.

Infection theory

Bacteria are able to invade and destroy the appendix when obstructed. Faecoliths in the old and lymphatic tissue in the young obstruct the appendix causing distal stasis that predisposes to infection.

Hygiene hypothesis

This attributes the initial rise to improved sewage disposal and water supplies. This altered children's immune response to later virus infections so that they now triggered appendicitis. The same hygiene factor is however thought to

explain the declining incidence. There are now fewer infections among adolescents.

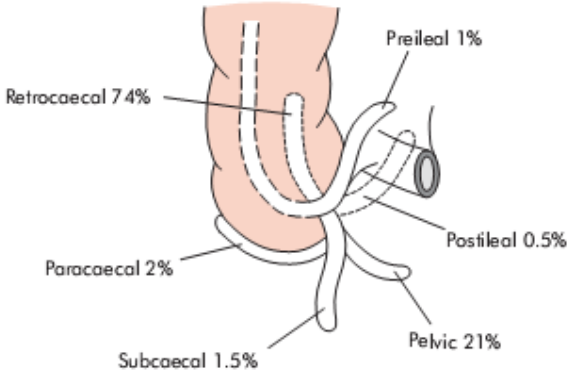
Other

Breast-feeding is a marker of some unknown socio-economic factor associated with low risk of appendicitis.

Potato consumption has also been curiously linked to the risk of appendicitis.

Anatomy

The appendix is a blind-ended tubular structure with an average length of 7.5cm. It is characteristically a human structure shared by only a few apes and the Australian wombat. It is longer in males and possesses a tiny lumen that admits a matchstick. It presents as an outpocketing from the caecum inferior to the ileocaecal junction with a variable position in relation to these structures. 74% of appendices are retrocaecal, 21% pelvic and the rest either post-ileal, paracaecal or pre-ileal[7].



Attached between it and the ileum is the mesentery (mesoappendix). This mesentery is laden with fat in the adult and the appendicular vessels within it are only visible in the child. The appendicular and accessory appendicular arteries, branches of the ileocolic artery from the superior mesenteric artery, supply it. These vessels lie on the free border of the mesentery but may lie directly on the wall of the appendix especially where the mesentery is lacking. The vessels become end-arteries once they reach the wall of the appendix. Thus thrombosis of the vessels would result in necrosis of the structure.

Histologically, the appendix has four layers like the rest of the intestinal tract. The mucosa is columnar with crypts that contain the Kultschinksy cell. These cells give rise to carcinoids. The mucosa has aggregations of lymphoid tissue, proliferation of which may block the lumen of the appendix. The peak incidence of appendicitis in childhood, adolescents and early adulthood coincide with the period of maximal lymphoid development(10). This lymphoid tissue atrophies with age. The muscular layer has inner circular and outer longitudinal layers, the representing the convergence of taenia coli of the caecum.

Embryology

The appendix develops as a derivative of the midgut loop at whose caudal limb the caecal diverticulum develops. The vermiform appendix develops as another diverticulum from the caecal diverticulum initially at the tip but because the right side of the caecum grows faster that the left wall, the appendix later comes

to lie on the left wall of the caecum. Soon after the return of the midgut to the abdomen following physiological herniation, the caecum is located subhepatically and later elongates to then lie in the right iliac fossa. Failure to do this may lead to subhepatic position of the appendix in the adult. Other congenital anomalies of the appendix may include appendicular agenesis, duplication and left- sided appendix. The latter is seen only in cases of situs inversus.

The surface projection of the appendix is the McBurneys point located by the junction of the lateral third and medial two thirds of a line joining the umbilicus to the anterior superior iliac spine. This is classically the point of maximum tenderness in acute appendicitis and the point where appendicular incisions namely Lanz, Gridiron and Rutherford Morrison are made.

Pathology

Acute appendicitis classically presents as transmural inflammation although there are situations where only the mucosa is affected and this is termed catarrhal appendicitis whose usual course is resolution. Its exact clinical significance is, however, still contentious. Grossly, an inflamed appendix appears swollen, roughened and in severe cases appears green or even black (gangrenous appendicitis).

Histopathological features of appendicitis may be summarised as:

(i) ulceration of the mucosa

(ii) polymorphonuclear cell-infiltration in all layers including the serosa

(iii) mucosal inflammation only in catarrhal appendicitis

(iv) abscess formation and

(v) mucin accumulation in appendicular mucocoele

There may also be associated inflammatory endarteritis and in upto 40% of cases, demonstrable faecoliths.

In an attempt to limit the spread of the inflammation, adjacent caecum, small intestine, large intestines and the greater omentum forming what is referred to as an appendicular mass may surround the appendix.

The results of appendicular inflammation would depend on whether the inflammation is obstructive or non-obstructive in nature. The majority of appendicitis is obstructive and may be followed by resolution, ulceration, suppuration, fibrosis or gangrene. Gangrene is twice as common[8] in obstructed than in non-obstructed appendicitis. Resolution is usual in non-obstructive forms.

Clinical features

A patient with acute appendicitis typically presents with sudden periumbilical pain that shifts to become maximal at the right iliac fossa. There is associated

anorexia, nausea and vomiting. The pain is made worse by coughing. The patient usually has mild pyrexia. This classical presentation is seen in only 50% of patients[8].

Other clinical features depend on the position of the appendix. In pelvic appendicitis, the patient may present with diarrhoea and frequency. Right upper quadrant pain is a feature in subhepatic appendicitis and in a pregnant patient. The appendix shifts to the upper quadrant in pregnancy. When examined, the patient appears flushed with marked tenderness at McBurney's point. More often however, because of the variable position of the appendix, the point of maximum tenderness is an area at the right iliac fossa rather than a point. There is rebound tenderness due to local peritonitis. It is important to note that the tenderness may be significantly reduced in situations where the appendix is either pelvic or retrocaecal. The inflamed pelvic appendix may cause spasm on the psoas major and obturator internus muscles - the basis for the psoas and obturator tests for appendicitis. These signs, as is Rovsing's sign are generally unreliable in the diagnosis of appendicitis.

A digital rectal examination is useful as the examiner elicits right-sided tenderness in pelvic appendicitis. A mass is palpated in the right iliac fossa in the case of an appendicular mass. The signs of appendicitis may be difficult to appreciate in the obese patient. In late presentation of appendicitis features of complications are usually evident.

Complications of appendicitis

1. Wound infections

2. Intra-abdominal abscess

3. Adhesion

4. Intestinal obstruction

5. Portal pyaemia

6. Bleeding

7. Deep Venous Thrombosis

8. Tubal infertility in females

9. Abdominal Actinomycoses

In the child, because of a shorter omentum and difficulty in arriving at the diagnosis as the disease may only present with anorexia and vomiting, perforation is common. With appendicular perforation the complication rate rises from 8% to over 30%[9]. In the elderly, the lax abdominal wall, fatty abdomen and frequent use of enemas may explain their high complication rates.

Differential diagnosis of appendicitis

Adults

(i) Acute cholecystitis

(ii) Acute pancreatitis

(iii) Intestinal obstruction

(iv) Perforated peptic ulcer

(v) Renal colic

(vi) Diverticular disease

(vii) Non-specific abdominal pain

Children

(i) Non-specific abdominal pain

(ii) Mesenteric adenitis

(iii) Intussusception

(iv) Urinary tract infection

(v) Hernia

(vi) Respiratory infection

Elderly

(i) Colorectal carcinoma

(ii) Vascular diseases

(iii) Medical causes

Women

(i) Pelvic inflammatory disease

(ii) Urinary tract infection

(iii) Ectopic pregnancy

(iv) Twisted ovarian cyst

Investigatory modalities

Blood Investigations:

Interleukin-6 (IL-6) can be used as a laboratory marker of acute appendicitis with perforation, but its accuracy is questionable[10,11] Inter-leukin-6 is a pro-inflammatory cytokine and an early marker of systemic inflammatory response and tissue damage.

IL-6 plays a important role in acute appendicitis by inducing the acute-phase responses such as neutrophilia or by the production of acute-phase proteins (eg, C-reactive protein)[12]. Below table illustrates labarotory values of CRP, ESR and WBC in control group, acute inflammatory group and suppurative group of patients.

		Appendicitis Groups			
Characteristics	Control Group	Normal Histology	Acute	Acute Suppurative	Total
Age	28.5 ± 11	24.6 ± 6	30 ± 13	30.7 ± 13	29.3 ± 12
Sex (m/f ratio)	0.9	0.4	0.5	1.6	1.1
Exudative (%)	—	0.8	16.2	43.9	60.9
CRP (mg/L)	3.2 ± 4.6	13.4 ± 20.3	24 ± 29.8	22.8 ± 30.3	21.5 ± 28.5
ESR (mm/hr)	7.3 ± 5.1	17.4 ± 11.9	26.2 ± 20.6	18.5 ± 12.6	20.7 ± 15.7
WBC (10^3/mm^3)	5.9 ± 1.2	10.6 ± 4.2	12.7 ± 2.9	13.2 ± 3.8	12.4 ± 3.8
Neutrophilia (%)	60 ± 7.4	69.6 ± 11.1	79.7 ± 7.6	75.5 ± 9.7	76.3 ± 10.6

IL-6 is a mediator of the inflammatory response and is reported as a marker for diagnosis, which could affect other inflammatory markers[10,12].

Interleukin-6 is a pro-coagulant cytokine which induces tissue factor (TF) mRNA expression. IL-6 also increases monocyte surface TF protein. It is also postulated that IL-6 production contributes to local thrombosis and thereby leading on to perforation and gangrene. IL-6 contributes to increased inflammatory response by delaying the neutrophil apoptosis and by promoting the neutrophil degranulation and elastase release.

In spite of these IL-6 roles, the primary source of IL-6 in plasma after abdominal surgery has not yet been clarified. Patient genetics and gene expression has been evaluated in several studies, and they have shown that TNF and IL-2 mRNA expression is a sensitive marker of inflammation in appendicitis.

It has been shown that concentrations of serum IL-6 (6,14) and IL-8 (14) were elevated in adults with acute appendicitis, especially with perforation; and the serum IL-6 level is a valuable tool in diagnosing advanced appendicitis.

Radiological procedures employed in the diagnosis of appendicitis include plain abdominal X-ray and abdominal ultrasonography and the CT scan. The obliterated psoas shadow, faecolith and focal ileus that depict appendicitis in an

abdominal X-ray are only seen by the most experienced radiologists. It is thus not useful to most people.

Criteria for Diagnosis of Acute Appendicitis by Abdominal ultrasound:

Features, which would suggest appendicitis, include[13]:

(i) Non-compressible appendix

(ii) Aperistaltic appendix

(iii) Appendicular diameter greater than 6 mm

(iv) Circumferential loss of submucosal layer and

(v) Presence of appendicolith (faecolith)

Signs of gangrenous appendicitis and perforation[13]

1. Loss of the echogenic submucosal layer
2. Fluid or other hypoechoic masses adjacent to the appendix.

Poor patient tolerance, obesity, gas in abdomen and unusual location of the appendix have been cited as the reasons for the reduced sensitivity. Combined with other diagnostic modalities, the diagnostic accuracy improves.

Criteria for Diagnosis of Acute Appendicitis by computed tomography:

A definitive diagnosis of acute appendicitis can be made using CT by the following pointers[13]

- A calcified appendicolith with pericecal inflammation.

- The inflamed appendix usually measures 7 to 15 mm in diameter.
- Periappendiceal inflammation is present in almost all patients.
- Focal cecal apical thickening
- The arrowhead sign - this occurs when the cecal contrast material funnels symmetrically towards the cecal apex to the point of appendiceal occlusion.
- Abscesses and inflammation are present when perforation of the appendix has occurred.
- Extraluminal air, enlarged lymph nodes, and small-bowel obstruction may be present.
- Contrast-enhanced CT may demonstrate the remains of a fragmented appendix.

Helical CT along with 3% diatrizoate meglumine (gastografin)-saline solution into the colon produces the highest accuracy.

Appendicular CT is safer than standard CT abdomen as it can be performed in approximately fifteen minutes and requires only one third of the radiation exposure.

The following table illustrates the diagnostic sensitivity and specificity of ultrasound and CT scan in percentage.

	CT range	Ultrasound range
Sensitivity	90-100	75-98
Specificity	91-99	86-100
Accuracy	94-98	87-96
PPV	92-98	91-99
NPV	89-99	89-98

[14]

Abdominal magnetic resonance imaging (MRI):

It valuable and safe technique for the evaluation of suspected appendicitis in pregnant women. MRI enables the accurate visualisation of the entire abdominal structures and the technique is free of radiation. But, the technique is restricted by its availability and the safety during pregnancy has not been proven definitely.

Diagnostic laparoscopy has recently gained more attention for its diagnostic properties and therapeutic possibilities. But the procedure is invasive and requires general anaesthesia. It is also costly. Therefore its place in the routine diagnosis of appendicitis remains to be seen.

Treatment

Urgent surgical removal of the inflammed appendix is the treatment of choice in most cases. This may be achieved via the open method or by laparoscopy.

Open Appendectomy

Incision

The classic McBurney incision is typically made at right angles to, and two-thirds along, the line between the umbilicus and the anterior superior iliac spine. A transverse or Rockey-Davis incision may be used at the same location. An incision made to lie in Langhans lines results in the best cosmetic result. A lower midline incision may be necessary in morbidly obese patients, or in patients who have a strong possibility of having other pelvic abnormalities.

Irrespective of the skin incision, a muscle-splitting incision holds the least likelihood of dehiscence or hernia. The external oblique aponeurosis is sharply incised parallel to the direction of its fibers. The internal oblique fascia and muscle is then bluntly separated using large clamps spread at right angles until the transversalis fascia is identified. The transversalis fascia and peritoneum are identified and sharply divided. On entry into the peritoneal cavity, Army-Navy, appendiceal, or small Richardson retractors may be used to further bluntly separate the abdominal wall musculature.

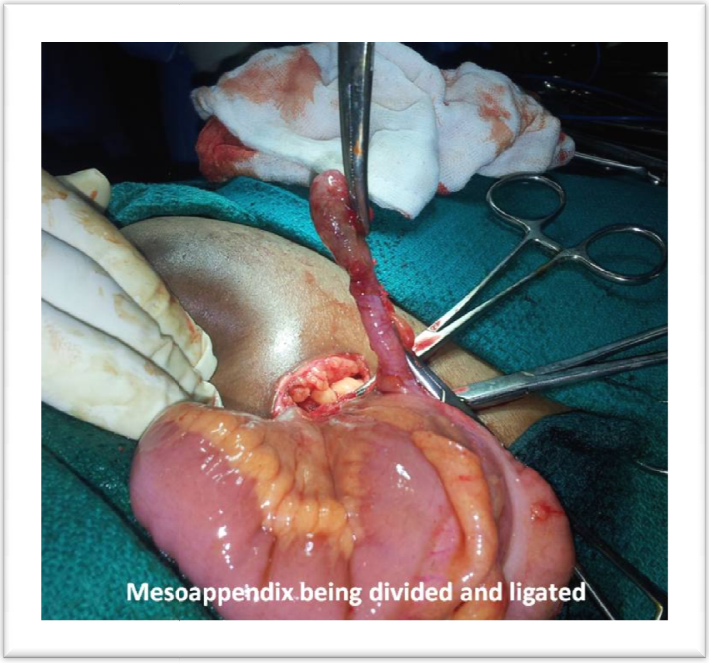
Exploration and Mobilization of the Appendix

A finger placed into the peritoneal cavity may be sufficient to identify and then deliver the appendix into the wound. If necessary, the anterior tenia of the cecum can be followed by gently grasping the cecum with moistened gauze and delivering it into the wound, using a rocking motion, until the base of the appendix is identified. If the appendix is retrocecal, medial mobilization of the

cecum is necessary to access the appendix; this can typically be done bluntly, with a finger, combined with sharp or electrocautery division of the tissue along the white line of Toldt.

Removal of the Appendix

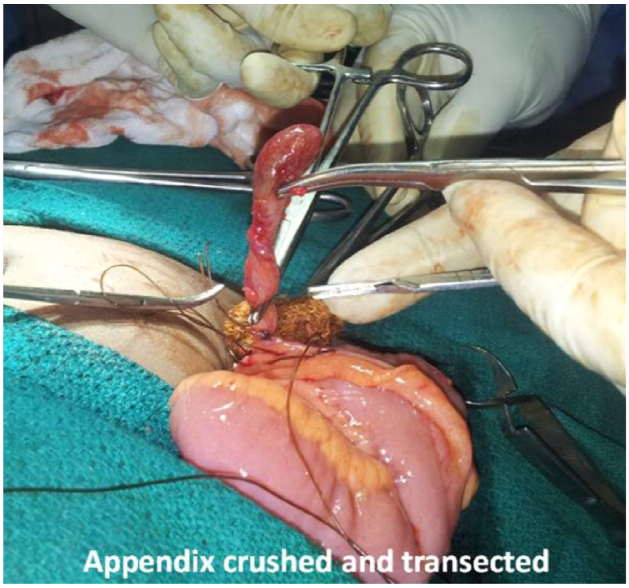
When the appendix has been mobilized sufficiently, the vascular arcade is divided between clamps and tied. This may be done in one step, at the base of the appendix, or, if the anatomy dictates, may be done in stepwise fashion along the mesoappendix, allowing for progressive mobilization along the length of the appendix until the base is reached.



The base of the appendix must be definitively identified at the cecum to avoid partial appendectomy.

The appendix is then crushed with a straight clamp approximately 3 mm from the cecum. The straight clamp is then moved approximately 3 mm more distally

onto the appendix and applied. The appendix is then ligated using a 2-0 or 0 ligature. A scalpel is used to transect the appendix on the proximal side of the straight clamp, thus avoiding any spillage from the appendix. This same scalpel may be used to cauterize the exposed mucosa of the appendiceal stump, and then removed with the specimen off the surgical field, minimizing contamination.



Inversion of the appendiceal stump is of questionable utility, when done, it can be simply accomplished using a purse-string or "Z" stitch placed around the base of the appendiceal stump. Irrigation of the peritoneal cavity with normal saline is typically performed, especially in patients with murky abdominal fluid, gangrenous appendicitis, or frank perforation. There are little data in the literature supporting or refuting this practice. There is no role for prophylactic drainage of a simple case of acute appendicitis.

Closure

The wound is closed in layers. Depending on the anatomy, closure of the peritoneum and transversalis fascia may be performed. If a muscle-splitting incision was used, there is no need to approximate anything other than the external oblique aponeurosis. Following irrigation with normal saline, closure of the skin and subcutaneous tissues is routine for all cases of appendicitis.

Conservative management for appendicitis is employed in the following situations:

(i) Presentation more than 48 hours

(ii) Appendicular abscess and

(iii) Established mass.

In the conservative management of these latter situations, the patients are put on intravenous antibiotics, fluids, and hourly observation of vital signs and repeated abdominal examination. If the signs and symptoms improve, interval appendicectomy is carried out a few months later. In the event of perforation as evidenced by increasing pulse rate, vomiting or increasing size of mass, emergency operation is undertaken. With the advent of good antibiotics and improved handling of peritoneal sepsis, the need for interval appendectomy is becoming obsolete. Many studies have concluded that antibiotic treatment was as effective as surgery save for the higher recurrence rate.

Laparoscopic Appendectomy

Patient position: Supine position with Trendelenburg and left lateral tilt

Surgeon position: On left of the patient

Assistant position: On the left of the patient

Monitor Position: On the right of the patient

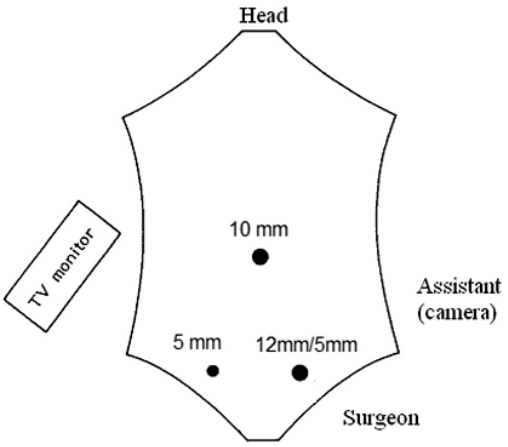
Port placements:

10 mm port – umbilical region

12 mm / 5 mm port – suprapubic region

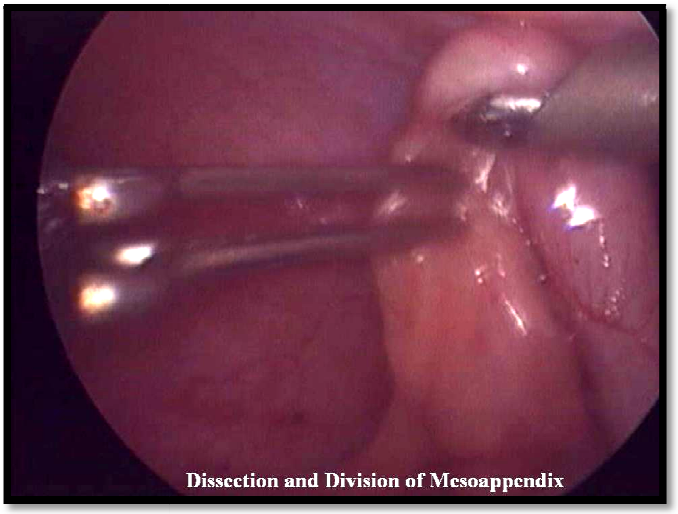
5 mm port – right lower abdomen

Anesthesia: General anaesthesia

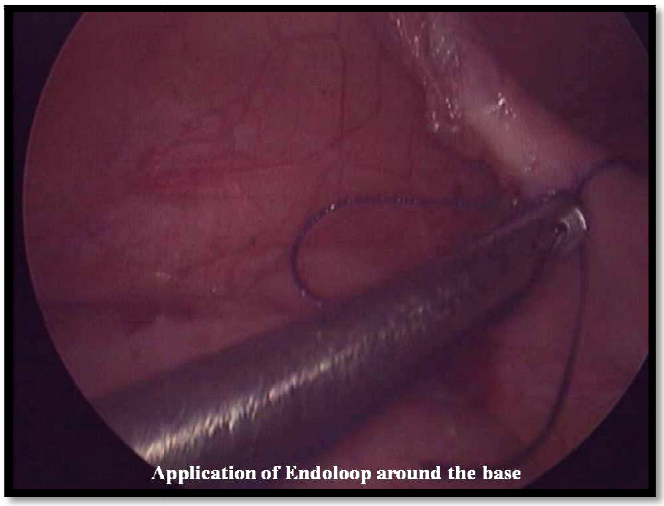


Operative technique:

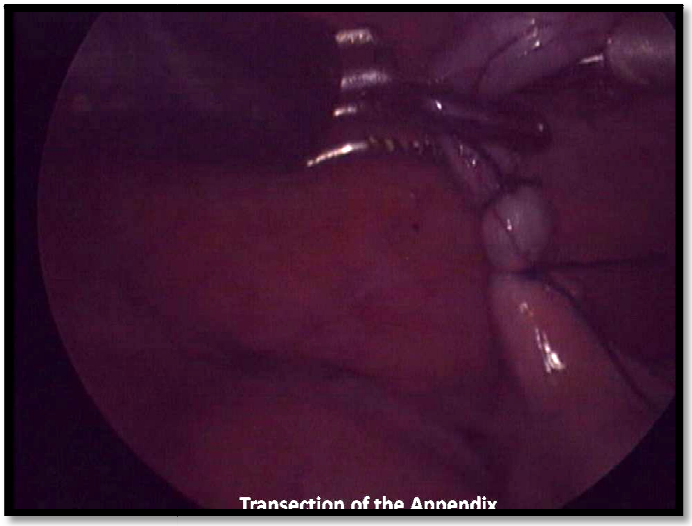
The appendix is grasped by its mesoappendix using a grasper. Mesoappendix is then skeletonised using a harmonic scalpel or and other energy source.



An endoloop is passed through the appendix upto the base and it is secured. Two more loops are passed distal to it leaving a gap of 5mm in between them.



The appendix is transected between the endoloops leaving two loops by the side of the caecum. The appendix is then received in a sterile specimen retrieval bag and delivered out through the suprapubic port.



Other methods of ligating the base is by using a linear stapler or a Hemolock clips.

Complications:

1. Bleeding
2. Fecolith
3. Incomplete appendectomy leading on to stump appendicitis
4. Stump leak
5. Post operative abscess
6. Wound infection

Acute appendicitis a continuing diagnostic challenge:

Traditionally, the diagnosis of acute appendicitis is made by history and physical examination. But the presenting symptoms and the clinical signs, being extremely variable the correct diagnosis of appendicitis remains a challenging task for the surgeon. The condition being elusive it is not surprising to note that the diagnosis is missed initially in 20% of patients with appendicitis and they become complicated and also in 15-40% of those undergoing emergency appendicectomy for suspected appendicitis, the appendix is found to be normal.[15]

The reason for negative appendicectomy may be due to the vagaries in presenting signs and symptoms and also due to the various differential diagnosis in tray for a single RIF pain.

The reasons for delay in seeking medical consultation are due to delay in referral from peripheral hospitals, lack of money to pay for the medical services and for transport. Delayed presentation is also due to misdiagnosis or fear of surgery as a result they are treated conservatively with analgesics and antibiotics to mask the symptoms. Delayed presentation is associated with increased morbidity and mortality due to appendiceal perforations and peritonitis. In developing countries, rates of between 6-65% have been quoted[16]. Delayed presentation, fulminate disease, misdiagnosis, or failure to accept surgical treatment, are contributory factors to high perforation rates. Perforation rates are much higher in the very young and the elderly, where diagnosis is often difficult leading to perforation rates as much as 80% in some reported series[16].

Unfortunately, most cases of acute appendicitis being missed usually have non-specific presentations. In the busy hospital environment an inexperienced physician may easily discharge these patients prematurely. Accurate diagnosis could have been made if these patients had been monitored for longer periods before being discharged. From various studies it is found out that diagnostic accuracy was found to increase with the seniority of emergency physicians.4 Longer observation time with repeated examinations by senior doctors will help in improving the diagnostic accuracy. There is still no single diagnostic mousetrap to capture the appendiceal rodent till today.

What is the Solution to the problem:

Different techniques have been devised to assist in equivocal cases in attempts to decrease negative appendectomy rates. Diagnostic scores are one such technique. These scores make use of history, physical examination and laboratory findings. Presently many scoring systems are found in literature of which six scoring system have been used widely to aid the diagnosis of acute appendicitis[17]

Clinical Scoring Systems (CSSs) have been developed to assist clinicians in appropriately stratifying a patient's clinical risk of having appendicitis.

An increase in the use of Clinical Prediction Rules (CPRs) to improve diagnostic accuracy has occurred over the last 2 decades. CPRs are tools that use specific criteria in order to establish probabilities of outcomes or to assist in management decisions. Some researchers have distinguished 3 types of CPRs; Diagnostic CPRs which focus on factors related to arriving at a clinical diagnosis; Prognostic CPRs which predict outcomes; and Prescriptive CPRs which provide recommendations for clinical intervention. (Beattie & Nelson, 2006)

CPRs have been defined as decision-making tools that include 3 or more variables obtained from the history, physical examination or basic diagnostic

tests in order to assist the clinician in decision making. (Laupacis, Sekar, & I. G. Stiell, 1997)

The format of a CPR can be variable, depending on the purpose. Some require fulfillment of a complete set of criteria in order to direct management. Others assign values to weighted criteria, the summation of which provides a score. These are often known as Clinical Scoring Systems (CSSs).

Some CSSs are dichotomous, utilizing a cutoff value above which an action is recommended or an outcome is expected. For example, surgical intervention may be recommended for a certain validated score over 6.

Others CSSs lean more toward a continuous nature to provide graded risk stratification. A simple example may stratify a patient to low risk of a disease process for scores of 1-2, moderate risk for scores of 3-5 and high risk for scores of 6-7.

While many CSSs exist, not all have been appropriately developed or evaluated. In the process of evaluation, one must consider several factors including the internal validity, accuracy, external validity, sensibility and potential impact (Beattie & Nelson, 2006).

McGinn et al have proposed a 4-level hierarchy to assist health care providers in determining the strength of CPRs and CSSs. Those that have been rigorously

tested, including impact analysis, are deemed Level 1, while those that have simply been derived but not tested are Level 4

Making wise, educated decisions is the cornerstone of good medical practice and often involves estimating the probability of an event. Inherent to all medical decisions is an assessment of potential risk and benefit.

While practice variation results in patient outcome differences, standardization of practice based on the best evidence can result in improved care

While practice variation results in patient outcome differences, standardization of practice based on the best evidence can result in improved care.

Various scoring systems:

1. Alvarado Score (MANTRELS)
2. Pediatric Appendicitis Score (Samuel)
3. Low Risk for Appendicitis Score (Kharbanda)
4. Lintula Score
5. Eskelinen Score
6. Teicher Score
7. Fenyo - Lindberg Score
8. Ohmann Score
9. Christian Score
10. RIPASA Score

The Alvarado Score (MANTRELS)

In 1986, Alvarado[18] published what is now one of the most well-known and studied appendicitis scores (Alvarado, 1986). This retrospective study of 305 patients admitted for suspected appendicitis evaluated common clinical and laboratory findings in relation to pathologically proven acute appendicitis. 277 patients were eligible for analysis.

Eight criteria were chosen for inclusion in the diagnostic score, weighted to represent joint probability of disease. The Diagnostic criteria for the Alvarado Score are shown in Table

Diagnostic Criteria	**Value**
Migration of pain to RLQ	1
Anorexia	1
Nausea-Vomiting	1
Tenderness in RLQ	2
Rebound Pain	1
Elevation of Temperature (≥37.3 C)	1
Leukocytosis (> 10 000)	2
Shift to Left (> 75%)	1
Total	10

Right Lower Quadrant (RLQ) Pain and a Left Shift were found to be the most prevalent, thus receiving 2 points each, while each of the remaining criteria were attributed 1 point. This initial study included both adults and children, with an age range of 4 to 80 years (mean 25.3).

An Alvarado Score of ≥7 was considered high risk for appendicitis. Though not explicitly stated in the study, this threshold value had a sensitivity of 81% and a specificity of 74%. Several elements of the score have been criticised, particularly the threshold for fever (37.3 C) and the availability of peripheral cell count differentials at some health centres, prompting some investigators to modify the score.

Modified Alvarado scoring system (MASS):

There are various modifications for Alvarado scoring system by different authors. Each of this modification is done for a particular population which needs a specific modification. One such accepted modification[20] worldwide is to neglect the shift to left criteria and to calculate the score for a maximum of 9.

Symptoms	Score
Migratory right iliac fossa pain	1
Nausea/Vomiting	1
Anorexia	1
Signs	
Tenderness in right iliac fossa	2
Rebound tenderness in right iliac fossa	1
Elevated temperature	1
Laboratory findings	
Leucocytosis	2
Total	**9**

Criteria:

7 and above: suggestive of acute appendicitis

< 7: Acute appendicitis excluded

Study	Year	Population	Ages	Design	T+	F+	F-	T-	Sens	Spec	PPV	NPV	Acc	Notes
Alvarado	1986	305 suspected appendicitis 277 included	4 to 80 years	Retrospective	184	13	43	37	81%	74%	93%	46%	80%	Derivation Study
Bond	1990	189 suspected appendicitis 143 included	2 to 17 years	Prospective	103	21	12	52	90%	71%	83%	81%	82%	
Owen	1992	215 suspected appendicitis 70 children	Not defined	Prospective	40	5	3	22	93%	81%	89%	88%	89%	Sub-group analysis
Kalan	1994	49 suspected appendicitis 11 children	Not defined	Prospective	11	0	0	0	100%	N/A	100%	N/A	100%	Modified Alvarado – No Left Shift
Macklin	1997	118 suspected appendicitis	4 to 14 years	Prospective	29	17	9	63	76%	79%	63%	88%	78%	Modified Alvarado – No Left Shift

The criteria used in Alvarado and Modified Alvarado are easy to elicit, each criteria is dichotomous (Yes/No), and the Score is easy to calculate.

Analysis of Alvarado score from previous studies[21]

Parameter	Males	Females	Total
Sensitivity	85.2%%	89.3%	87.3%
Specificity	57.1%	53.8%	55%
PPV	88.5%	80.6%	84.2%
NPV	50%	70%	61.1%

Analysis of Modified Alvarado score from previous studies[20]

Sensitivity	94.1%
Specificity	90.4%
Positive Predictive Value	95.2%
Negative Predictive Value	88.4%
Diagnostic Accuracy	92.9%

The Fenyo-Lindberg Score

This score appears to be one of the most complex, incorporating criteria with multiple levels of response that both add to and subtract from the total score. In 1987, Fenyo[19] prospectively evaluated 259 adult patients with suspected

appendicitis. The resulting score was further validated in 830 patients, of which 256 had proven appendicitis. Sensitivity, Specificity, PPV and NPV were 90%, 91%, 83% and 95% respectively[19]. Criteria to diagnose acute appendicitis

All patients start with -10

-2 or higher: acute appendicitis

-17 or lower: appendicitis excluded

-16 to -1: observation

Diagnostic Criteria	Response	Value
Sex	Male Female	+8 -8
WBC	≥14 9.0 – 13.9 ≤8.9	+10 +2 -15
Duration of Pain (hours)	<24 24 – 48 >48	+3 0 -12
Progression of Pain	Yes No	+3 -4
Relocation of pain	Yes No	+7 -9
Vomiting	Yes No	+7 -5
Aggravation by coughing	Yes No	+4 -11
Rebound Tenderness	Yes No	+5 -10
Rigidity	Yes No	+15 -4
Tenderness outside RLQ	Yes No	-6 +4
Constant		-10

Fenyo and Lindberg prospectively validated their score in 1167 patients with suspected appendicitis. Of these, 392 had histologically proven appendicitis. Using the standard threshold score of -2 to predict appendicitis, the sensitivity was 73% and specificity was 87%, notably less than in the original study. Of note, this study made use of 2 different settings, a district and a university hospital. 30% of the patients included from the University hospital were children (age unknown) (Fenyö, Lindberg, Blind, Enochsson, & Oberg, 1997).

Analysis of Fenyo's score from previous studies[21]

Parameter	Males	Females	Total
Sensitivity	100%	93.3%	97.3%
Specificity	71.4%	50%	56.5%
PPV	84.6%	45.2%	63.2%
NPV	62.5%	80%	72%

The Ohmann Score

In 1999, Ohmann[22] prospectively validated his own score in a multi-centre, multi-phase trial. Subjects evaluated during phase 1 (n=870) received surgical intervention based on surgeon assessment, while those in phase 2 (n= 614) received computer-assisted diagnostic support using the Ohmann Score. Children less than 6 were excluded from the study; overall pediatric numbers

were not published. The authors found a statistically significant improvement in specificity, PPV and accuracy in the phase 2.

Diagnostic Criteria	Value
Tenderness in the RLQ	4.5
Rebound Tenderness	2.5
No Micturation Difficulties	2.0
Steady Pain	2.0
WBC > 10	1.5
Age < 50	1.5
Relocation of pain to RLQ	1.0
Rigidity	1.0
Maximum Total Score	**16**

Criteria:

< 6 – appendicitis excluded

6 – 11.5 – Observation

> 11.5 – Suggestive of appendicitis

Score group, along with a decrease in the number of delayed diagnoses (defined as appendectomy on the second day after admission or later) (Ohmann 1999). Several studies have evaluated the Ohmann Score. In a large study of 2359 subjects (age 0 - 95 years) Zielke compared the score to clinical assessments. Overall accuracy using the Ohmann Score was found to be better than junior

surgical staff, with sensitivity, specificity, PPV, NPV and accuracy of 63%, 93%, 77%, 86% and 84%.

Analysis of Ohmann's score from previous studies[21]

Parameter	Males	Females	Total
Sensitivity	94.4%	82.6%	87.8%
Specificity	43.8%	33.3%	38.2%
PPV	65.4%	61.3%	63.2%
NPV	85.5%	60%	72.2%

Teicher Score

In 1983, IRA Teicher[23] proposed a scoring system to diagnose acute appendicitis. A retrospective study was carried out comparing demographic data, symptoms, signs, and laboratory findings in two groups of patients who were subjected to appendectomy. The research protocol was comprised of 23 items which were thought to be predictive of appendicitis, and included details of demographics, history, physical examination and laboratory findings. Diagnostic scores were computed for each patient using the seven statistically significant factors with nonzero weights. Scores were found to range from -11 to + 11.

The scoring is as follows

Variable	Score
Sex: Male Female	 +2 -1
Age: 20- 39 yrs > 40 yrs	 -1 +3
Duration of pain 1 day 2 days 3 days	 +2 +1 -3
Genitourinary symtoms Yes No	 -3 0
Muscle spasm in RLQ Involuntary None	 +3 -3
Rectal Mass (rt) Yes No	 -3 0
WBC count < 10,000 > 13,000	 -3 +2

Score of

> -3 is suggestive of appendicitis

< -7 is suggestive of Non specific abdominal pain

- 7 to -3 is placed under observation

Analysis of Teicher score from previous studies[21]

Parameter	Males	Females	Total
Sensitivity	91.3%	100%	93.9%
Specificity	80%	85.7%	83.3%
PPV	80.8%	32.3%	54.4%
NPV	50%	60%	55.6%

The RIPASA Score:

The newest member to the group of appendicitis scores is the RIPASA Score[24], named after its hospital of origin in Brunei. A mixed population of 400 adults and children who had an appendectomy were retrospectively identified, the records of 312 were used to derive the score. Individual criteria were weighted (0.5, 1, 2) based on probabilities and a panel of staff surgeons. The resulting maximal RIPASA score is 16; a threshold of 7.5 proving a sensitivity of 88% and specificity of 67% PPV and NPV were 93% and 53%, while accuracy was 81%. Using the score, an absolute reduction in negative appendectomies of9% would have occurred.

Diagnostic Criteria	Value
Sex	1.0 – Male 0.5 – Female
Age	1.0 - < 39.9 years 0.5 - > 40 years
RLQ pain	0.5
Migration of RLQ pain	0.5
Anorexia	1.0
Nausea & Vomiting	1.0
Duration of Symptoms	1.0 - < 48 hours 0.5 - > 48 hours
RLQ tenderness	1.0
RLQ guarding	2.0
Rebound tenderness	1.0
Rovsig Sign	2.0
Fever (not defined)	1.0
Raised WBC (not defined)	1.0
Negative Urinalysis (no blood, neutrophils, bacteria)	1.0
Foreign National registration Identity Card	1.0

Importance of scoring systems:

Over the last 2 decades, there has become increased reliance on Diagnostic Imaging modalities (DI) to confirm or rule out appendicitis and potentially provide alternate diagnoses (particularly in post-menarche girls). Given the availability of DI including Ultrasonography (U/S) and Computed Tomography (CT), and the relatively high sensitivity and specificity of these tests, they are often requested by the surgical team in order to improve diagnostic accuracy and decrease the rate of negative appendectomy.

However, given recent concerns related to radiation exposure in children (Brenner & Hall, 2007), as well as overcrowding in many EDs and DI

departments leading to delays in imaging acquisition, a more responsible approach to risk stratification is required.

Realistically, it is difficult to achieve 100% uptake of CSSs. Careful planning, with input from all key stakeholders is vital.

Conclusion

Due to the often difficult task of the early identification of appendicitis in children, the development of CSSs has increased over the last 3 decades. Overall, these scores have been shown to improve clinical and process outcomes including reduced negative appendectomy rates, reduced radiation exposure from unwarranted DI studies, and reduced missed diagnoses. However, one must remain optimistically cautious; to date these Scores have yet to demonstrate a sensitivity or specificity sufficient enough to recommend their use beyond calculated risk stratification (low, moderate or high).

Even with the abundance of literature regarding CSSs related to appendicitis, the need for well-designed, prospective studies to further validate the scores, evaluate implementation strategies and assess impact provides ample opportunity for future research. Due to the vast number of CSSs and the significant variability in the quality and quantity of validation studies, implementing Clinical Scores into practice can be challenging for individual

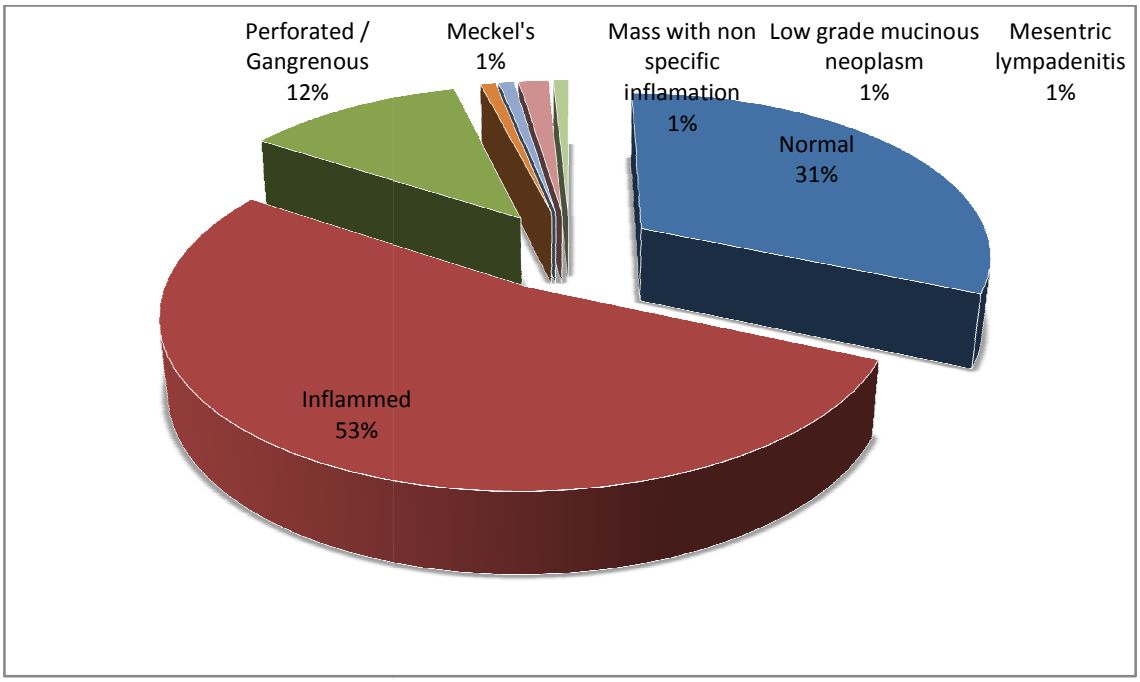
clinicians. Departmental leaders should therefore carefully consider incorporating CSSs into locally driven Evidence Based Clinical Algorithms.

RESULTS AND DISSCUSION

Total number of patients registered in the study was 127. They were classified as acute appendicitis and non acute appendicitis patients based on their appendicular macroscopic and microscopic findings. Among the acute appendicitis category they were sub classified into inflamed and perforated or gangrenous.

Macroscopic / Microscopic	Number
Normal	40
Inflammed	67
Perforated / Gangrenous	15
Others	
Mucocele of appendix	1
Meckel's	1
Mesentric lympadenitis	2
Mass with non specific inflamation	1
Total	127

From the table it was evident that acute inflammation of appendix was found in 82 patients (65%) and there was no acute inflammation in 45 patients. There was a negative appendicectomy rate of 35%.

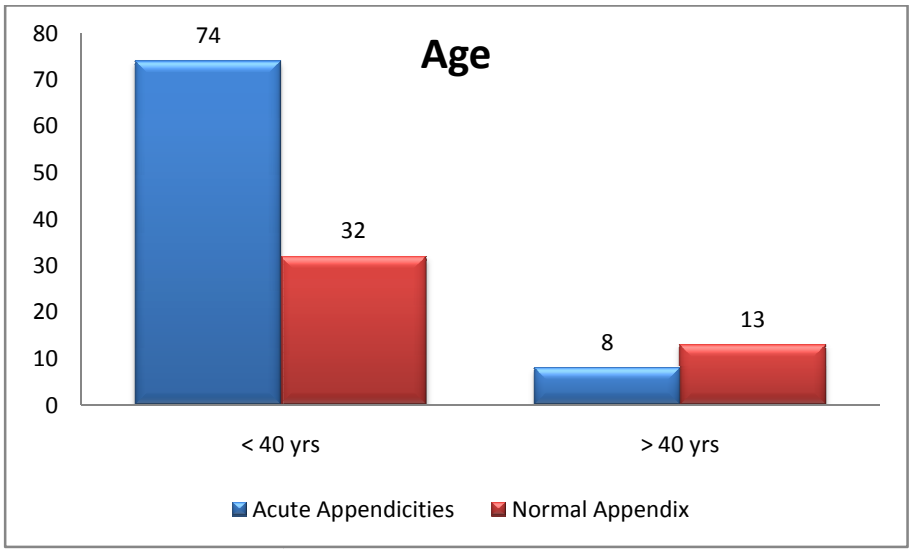


Pie chart to illustrate the Macroscopic & Microscopic findings in study population

Correlation with age:

Age	< 40 yrs	> 40 yrs
Acute Appendicitis	74	8
Normal Appendix	32	13

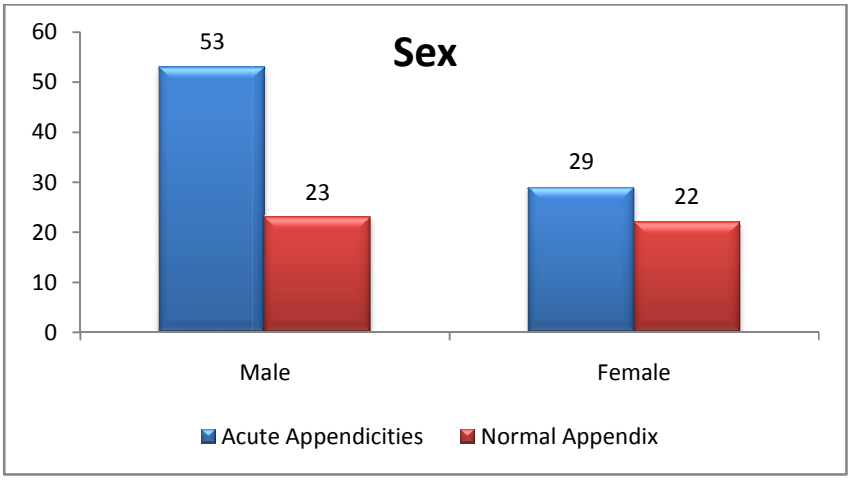
Acute appendicitis was more common in age group less than 40 years with more than 90% of patients with appendicitis being less than 40 years of age. p value is **0.011** and is statistically significant (p value < 0.05)



Correlation with sex:

Sex	Male	Female
Acute Appendicitis	53	29
Normal Appendix	23	22

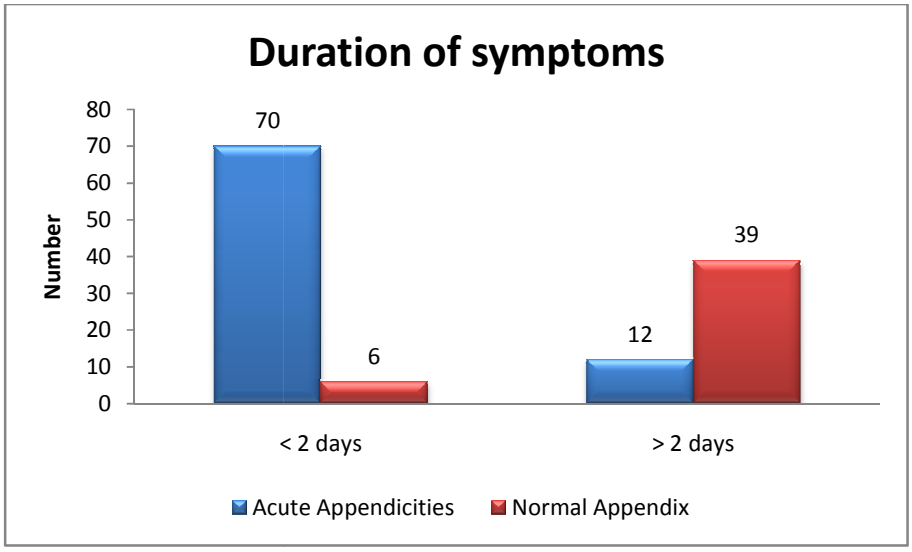
There was no statistically significant correlation noted in the incidence of acute appendicitis based on the patient's sex. (p value = 0.197)



Correlation with duration of symptoms:

Duration	< 2 days	> 2 days
Acute Appendicities	70	12
Normal Appendix	6	39

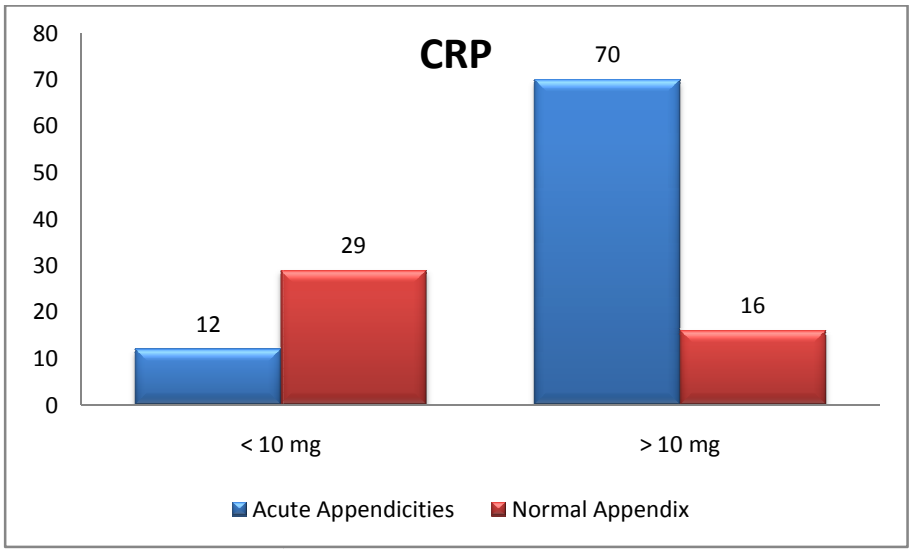
The occurrence of acute appendicitis was significantly higher when the duration of symptoms was less than 2 days. This p value is < 0.001 and is statistical significant.



Correlation with CRP levels:

CRP levels (mg/dl)	< 10 mg	> 10 mg
Acute Appendicities	12	70
Normal Appendix	29	16

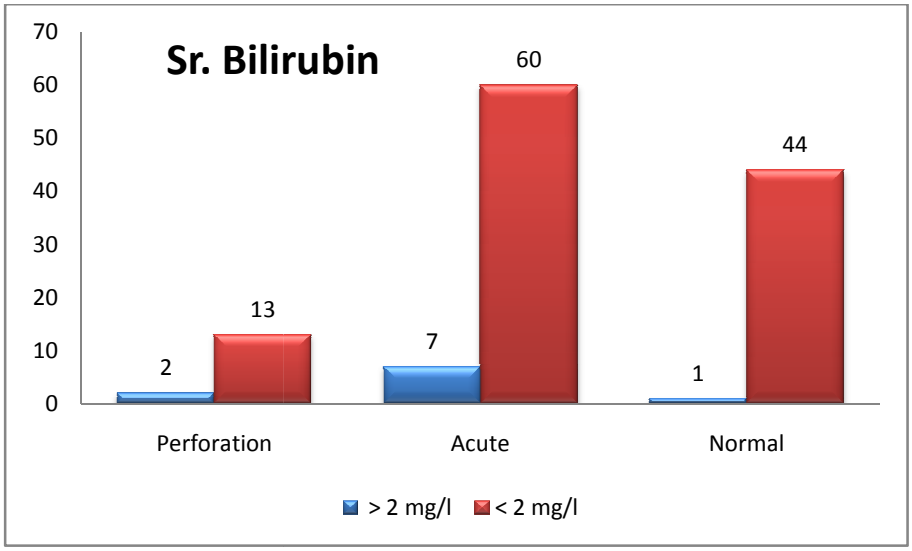
When the C reactive protein levels were higher than 10 mg/dl, the occurrence of acute appendicitis was significantly higher than in the patients with levels less than 10 mg /dl. The p value is < 0.001



Correlation with serum bilirubin levels:

Sr. Bilirubin (mg/dl)	< 2 mg	> 2mg
Acute Appendicities	73	9
Normal Appendix	44	1

The occurrence of acute appendicitis did not have any significant correlation with the serum bilirubin levels when the cut off was placed at 2 mg/dl in this study. (p value = 0.159)



		Disease (Appendicular perforation)		
		(+)	(-)	
Exposure (bilirubin > 2 mg/l)	(+)	2	7	9
	(-)	13	60	73
		15	67	82

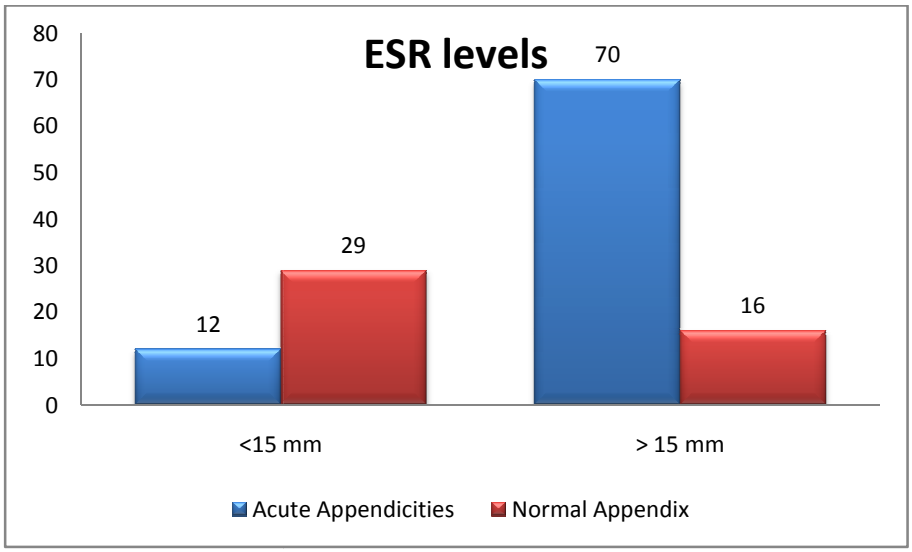
	Value	P value
Yates corrected chi square	0.01788	0.8936

There was no statistical significance in the relationship between the serum bilirubin level of > 2 mg/dl and the incidence of appendicular perforation.

Correlation with Erythrocyte sedimentation rate

ESR (mm/hr)	<15 mm	> 15 mm
Acute Appendicities	12	70
Normal Appendix	29	16

When the ESR levels were higher than 15 mm/hr, the occurrence of acute appendicitis was significantly higher than in the patients with levels less than 10 mg /dl. The p value is < 0.001



ANALYSIS OF EACH SCORING SYSTEM

Analysis for Alavarado score:

Score	Acute Inflammation	Others	Total
3	0	8	8
4	1	14	15
5	2	13	15
6	8	5	13
7	9	0	9
8	13	4	17
9	26	1	27
10	23	0	23
	82	45	127

When the cut off score was calculated at a score of 4 and above the following results were obtained.

Sensitivity	**100%**
Specificity	**17.78%**
Positive Predictive Value	**68.91%**
Negative Predictive Value	**100%**
Diagnostic Accuracy	**70.87%**

When the cut off score was calculated at a score of 5 and above the following results were obtained.

Sensitivity	**98.78%**
Specificity	**48.89%**
Positive Predictive Value	**77.88%**
Negative Predictive Value	**95.65%**
Diagnostic Accuracy	**81.10%**

When the cut off score was calculated at a score of 6 and above the following results were obtained.

Sensitivity	**96.34%**
Specificity	**77.78%**
Positive Predictive Value	**88.76%**
Negative Predictive Value	**92.11%**
Diagnostic Accuracy	**89.76%**

When the cut off score was calculated at a score of 7 and above the following results were obtained.

Sensitivity	**86.59%**
Specificity	**88.89%**
Positive Predictive Value	**93.42%**
Negative Predictive Value	**78.43%**
Diagnostic Accuracy	**87.40%**

In the previous studies which were done based on Alvarado score this cut off score has been used.

The following results were obtained when the cut off score was calculated at 8 and above.

Sensitivity	**75.61%**
Specificity	**88.89%**
Positive Predictive Value	**92.54%**
Negative Predictive Value	**66.67%**
Diagnostic Accuracy	**80.31%**

The following results were obtained when the cut off score was calculated at 9 and above.

Sensitivity	**59.76%**

Specificity	**97.78%**
Positive Predictive Value	**98%**
Negative Predictive Value	**57.14%**
Diagnostic Accuracy	**73.23%**

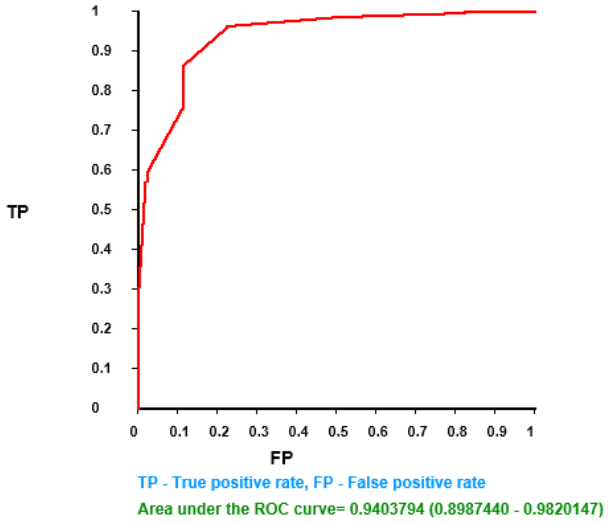
The following results were obtained when the cut off score was calculated at 10 and above.

Sensitivity	**28.05%**
Specificity	**100%**
Positive Predictive Value	**100%**
Negative Predictive Value	**43.27%**
Diagnostic Accuracy	**53.54%**

It could be noted that on increasing the cut off score the specificity of the score increased but a compromise had to be made on the sensitivity. The optimum cut off score is set at 7 as per previous studies to have a better standoff between sensitivity and specificity i.e. 86.59% and 88.89% respectively.

Receiver Operator Characteristic (ROC) Curve for Alvarado score:

The receiver operator characteristic (ROC) curve was plotted for the Alvarado score and the area under the curve was calculated. The area under the curve is 0.94.



ROC curve for Alvarado score

Analysis of Modified Alvarado score (MASS):

Score	Positive	Negative	Total
3	0	8	8
4	2	15	17
5	4	12	16
6	10	2	12
7	15	7	22
8	26	1	27
9	25	0	25
	82	45	127

The following results were obtained when the cut off score was calculated at 4 and above.

Sensitivity	**100%**
Specificity	**17.78%**
Positive Predictive Value	**68.91%**
Negative Predictive Value	**100%**
Diagnostic Accuracy	**70.87%**

The following results were obtained when the cut off score was calculated at 5 and above.

Sensitivity	**97.56%**
Specificity	**51.11%**
Positive Predictive Value	**78.43%**
Negative Predictive Value	**92%**
Diagnostic Accuracy	**81.10%**

The following results were obtained when the cut off score was calculated at 6 and above.

Sensitivity	**92.68%**
Specificity	**77.78%**
Positive Predictive Value	**88.37%**
Negative Predictive Value	**85.37%**
Diagnostic Accuracy	**87.40%**

The following results were obtained when the cut off score was calculated at 7 and above.

Sensitivity	**80.49%**
Specificity	**82.22%**
Positive Predictive Value	**89.19%**
Negative Predictive Value	**69.81%**
Diagnostic Accuracy	**81.10%**

The following results were obtained when the cut off score was calculated at 8 and above.

Sensitivity	**62.20%**
Specificity	**97.78%**
Positive Predictive Value	**98.08%**
Negative Predictive Value	**58.67%**
Diagnostic Accuracy	**74.80%**

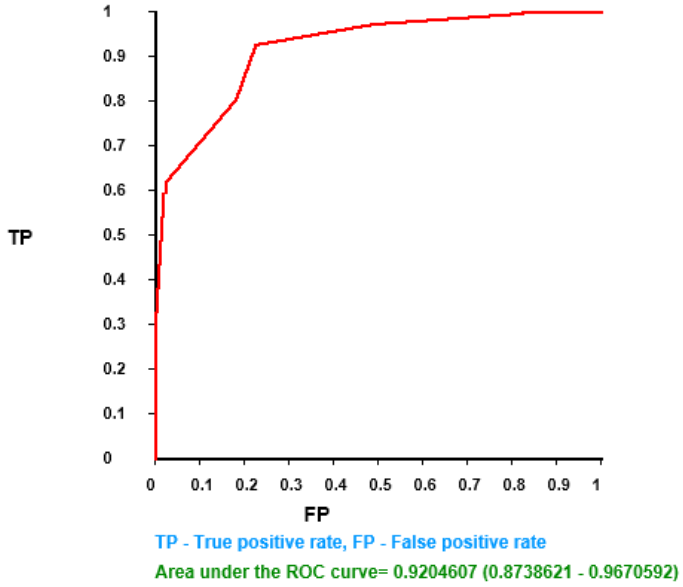
The following results were obtained when the cut off score was calculated at 9 and above.

Sensitivity	**30.49%**
Specificity	**100%**
Positive Predictive Value	**100%**
Negative Predictive Value	**44.12%**
Diagnostic Accuracy	**55.12%**

Upon increasing the cut off score the ability of the test to diagnose patients correctly increased but the possibility of missing a few cases was also noted. When the cut off score was placed at 7 as per previous studies, it could be noted

that the sensitivity, specificity was 80.49 and 82.22 respectively. The positive predictive value and diagnostic accuracy was better.

Receiver Operator Characteristic (ROC) Curve for MASS



ROC curve for Modified Alvarado score

The receiver operator characteristic (ROC) curve was plotted for the Modified Alvarado score and the area under the curve was calculated. The area under the curve is 0.92.

Analysis for IRA Teicher score:

Score	Positive	Negative	Total
< - 7	0	34	34
-7 to - 3	2	3	5
> - 3	80	8	88
	82	45	127

When the score was < - 7 there was no patient with acute appendicitis and when the score between - 7 to - 3 (observation group) there was equivocal response and the patients can be observed.

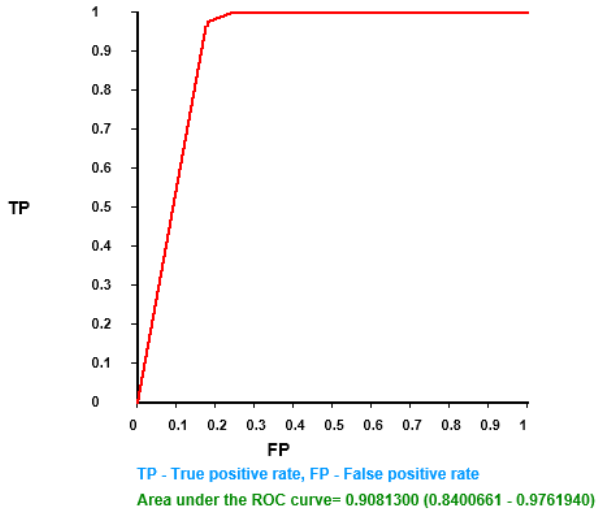
As per the Teicher's original report[23], when the patients in the surgery group (score > - 3) were operated the following results were obtained.

Sensitivity	**97.56%**
Specificity	**82.22%**
Positive Predictive Value	**90.91%**
Negative Predictive Value	**94.87%**
Diagnostic Accuracy	**92.13%**

This scoring system had a higher sensitivity and diagnostic accuracy but the specificity was low.

Receiver Operator Characteristic (ROC) Curve for Tiercher score

The receiver operator characteristic (ROC) curve was plotted for the Tiercher's score and the area under the curve was calculated. The area under the curve is 0.90.



Analysis of Ohmann's score

Score	Positive	Negative	Total
< 6	0	5	5
6 - 11.5	3	35	38
> 11.5	79	5	84
	82	45	127

When the cut off was placed at less than 11.5 only 3 patients had acute appendicitis out of the 43 patients. The following results were obtained.

Sensitivity	**100%**
Specificity	**11.11%**
Positive Predictive Value	**67.21%**
Negative Predictive Value	**100%**
Diagnostic Accuracy	**68.50%**

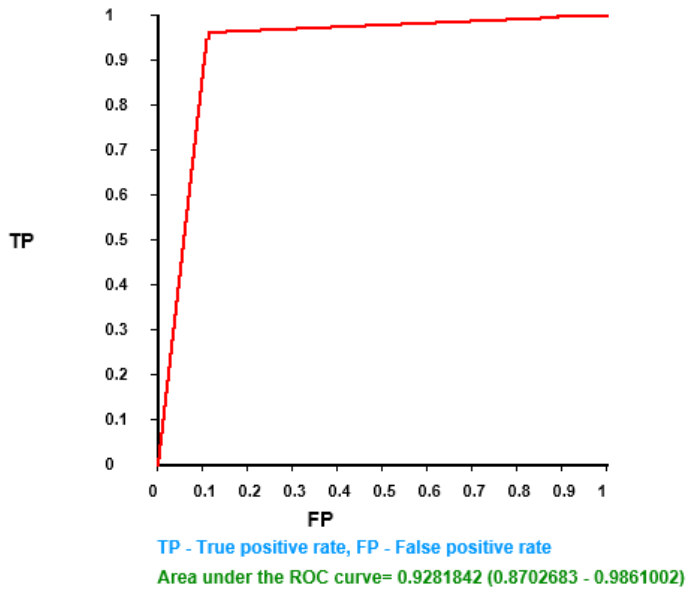
When the cut off was placed at greater than or equal to 11.5 only 5 patients did not have acute appendicitis out of the 84 patients. The following results were obtained.

Sensitivity	**96.34%**
Specificity	**88.89%**
Positive Predictive Value	**94.05%**
Negative Predictive Value	**93.02%**
Diagnostic Accuracy	**93.70%**

Ohmann's score of more than 11.5 has higher sensitivity, PPV, NPV and diagnostic accuracy but comparatively lower specificity.

Receiver Operator Characteristic (ROC) Curve for Ohmann's score

The receiver operator characteristic (ROC) curve was plotted for the Ohmann's score and the area under the curve was calculated. The area under the curve is 0.93.



ROC curve for Ohmann's score

Analysis for Fenyo's score:

Score	Positive	Negative	Total
< -17	12	43	55
- 16 to 1	20	1	21
> 2	50	1	51
	82	45	127

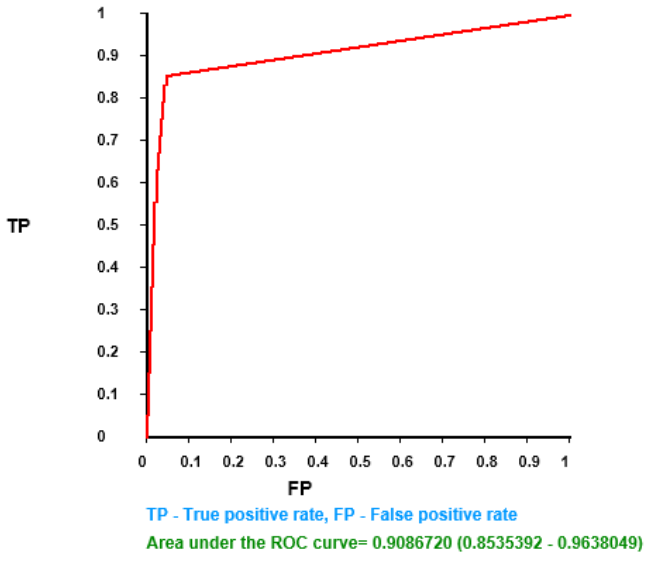
When the cut off score was placed at 1, there were a total of 76 patients and out of them 32 patients had acute appendicitis. The various parameters are as follows

Sensitivity	**85.37%**
Specificity	**95.56%**
Positive Predictive Value	**97.22%**
Negative Predictive Value	**78.18%**
Diagnostic Accuracy	**88.98%**

When the cut off score was placed at 2, there were a total of 51 patients and out of them 50 patients had acute appendicitis. But the main drawback is that this scoring has failed to diagnose nearly 40% of patients with acute appendicitis at this cut off score.

Sensitivity	**60.98%**
Specificity	**97.78%**
Positive Predictive Value	**98.04%**
Negative Predictive Value	**57.89%**
Diagnostic Accuracy	**74.02%**

Receiver Operator Characteristic (ROC) Curve for Fenyo's Score:



The receiver operator characteristic (ROC) curve was plotted for the Fenyo's score and the area under the curve was calculated. The area under the curve is 0.90.

Analysis for RIPASA score:

Score	Positive	Negative	Total
> 7.5	80	8	88
< 7.5	2	37	39
	82	45	127

With the cut off value placed at 7.5, the patients were analysed and the various parameters were calculated and results are tabulated below

Sensitivity	**97.56%**
Specificity	**82.22%**
Positive Predictive Value	**90.91%**
Negative Predictive Value	**94.87%**
Diagnostic Accuracy	**92.13%**

Formulation of a New combined predictor score:

From the previous studies the potential predictors of acute appendicitis were identified and they were analysed for individual patients.

List of Potential Predictors

1. Age
2. Sex
3. Duration of symptoms
4. Location of initial pain
5. Migration of pain to RIF
6. Anorexia
7. Vomiting
8. Dysuria
9. RIF tenderness
10. Rebound Tenderness
11. Guarding
12. Rigidity
13. Rousing's Sign
14. PR Tenderness
15. Fever
16. Total WBC count
17. Differential count
18. CRP
19. ESR
20. Urine Analysis
21. Serum bilirubin
22. Culture sensitivity of the pus from the appendicular stump

The sensitivity, specificity, risk ratio and chi square and p values were calculated for all the potential predictors. They were as follows.

Potential Predictor	Sensitivity	Specificity	Risk Ratio	Yates corrected chi-square	P value
Age	90.24	28.89	1.83	6.38	**0.011**
Sex	64.63	48.89	1.22	1.64	0.19
Duration of symptoms (< 2 days)	85.37	86.67	3.91	59.77	**<0.001**
Location of initial pain	85.37	28.89	1.43	2.89	0.09
Migration of pain to RIF	95.12	33.33	3.43	16.32	**<0.001**
Anorexia	9.24	40	2.28	14.52	**<0.001**
Vomiting	80.49	46.67	1.69	9.10	**0.002**
Dysuria	3.66	33.33	0.10	56.75	**<0.001**
Rebound Tenderness	70.73	95.56	2.69	48.6	**<0.001**
Guarding	85.37	97.78	4.6	78.14	**<0.001**
Rigidity	31.71	93.33	1.57	8.97	**0.003**
Rousing's Sign	76.83	97.78	3.26	61.74	**<0.001**
PR Tenderness	13.41	86.67	1.00	0.07	0.79
Fever	68.29	95.56	2.56	45.2	**<0.001**
Total WBC count	79.27	71.11	2.40	29.03	**<0.001**
N > 75%	80.49	82.22	2.95	44.45	**<0.001**
CRP	85.37	64.44	2.78	30.74	**<0.001**
ESR	85.37	64.44	2.78	30.74	**<0.001**
Urine Analysis	7.32	37.78	0.22	41.92	**<0.001**
Serum bilirubin	10.98	97.78	1.44	1.98	0.16

List of Significant Predictors:

From the above mentioned table the predictors which were statistically significant i.e. **$p < 0.05$** are identified as significant predictors. They were as follows.

1. Age
2. Duration < 2 days
3. Migration of pain to RIF
4. Anorexia
5. Vomitting
6. No history of Dysuria
7. Rebound Tenderness
8. Guarding
9. Rigidity
10. Rousing's Sign
11. Fever
12. Leukocytosis
13. N > 75%
14. CRP > 10
15. ESR > 15 mm
16. Urine Analysis Negative

Each of this predictor is given **1 point**. They were not scored based on their risk ratio to make this scoring system simple and dichotomous. The total score is **16**.

This scoring system was applied to all the patients individually and the scores ranged from 1 to 15.

Analysis of New combined predictor score:

Score	Positive	Negative	Total
1	0	4	4
2	0	4	4
3	0	11	11
4	0	5	5
5	0	2	2
6	0	3	3
7	1	4	5
8	0	6	6
9	3	4	7
10	3	2	5
11	8	0	8
12	13	0	13
13	19	0	19
14	20	0	20
15	15	0	15
	82	45	127

When the cut off score was calculated at a score of 2 and above the following results were obtained.

Sensitivity	**100%**
Specificity	**8.89%**
Positive Predictive Value	**66.67%**
Negative Predictive Value	**100%**
Diagnostic Accuracy	**67.72%**

When the cut off score was calculated at a score of 3and above the following results were obtained.

Sensitivity	**100%**
Specificity	**17.78%**
Positive Predictive Value	**68.91%**
Negative Predictive Value	**100%**
Diagnostic Accuracy	**70.87%**

When the cut off score was calculated at a score of 4 and above the following results were obtained.

Sensitivity	**100%**
Specificity	**42.22%**
Positive Predictive Value	**75.93%**
Negative Predictive Value	**100%**
Diagnostic Accuracy	**79.53%**

When the cut off score was calculated at a score of 5 and above the following results were obtained.

Sensitivity	**100%**
Specificity	**53.33%**
Positive Predictive Value	**79.61%**
Negative Predictive Value	**100%**
Diagnostic Accuracy	**83.46%**

When the cut off score was calculated at a score of 6 and above the following results were obtained.

Sensitivity	**100%**
Specificity	**57.78%**
Positive Predictive Value	**81.19%**
Negative Predictive Value	**100%**
Diagnostic Accuracy	**85.04%**

When the cut off score was calculated at a score of 7 and above the following results were obtained.

Sensitivity	**100%**
Specificity	**64.44%**
Positive Predictive Value	**83.67%**
Negative Predictive Value	**100%**
Diagnostic Accuracy	**87.40%**

When the cut off score was calculated at a score of 8 and above the following results were obtained.

Sensitivity	**98.78%**
Specificity	**73.33%**
Positive Predictive Value	**87.10%**
Negative Predictive Value	**97.06%**
Diagnostic Accuracy	**89.76%**

When the cut off score was calculated at a score of 9 and above the following results were obtained.

Sensitivity	**98.78%**
Specificity	**86.67%**
Positive Predictive Value	**93.10%**
Negative Predictive Value	**97.50%**
Diagnostic Accuracy	**94.49%**

When the cut off score was calculated at a score of **10** and above the following results were obtained.

Sensitivity	**95.12%**
Specificity	**95.56%**
Positive Predictive Value	**97.50%**
Negative Predictive Value	**91.49%**
Diagnostic Accuracy	**95.28%**

When the cut off score was calculated at a score of 11 and above the following results were obtained.

Sensitivity	**91.46%**
Specificity	**100%**
Positive Predictive Value	**100%**
Negative Predictive Value	**86.54%**
Diagnostic Accuracy	**94.49%**

When the cut off score was calculated at a score of 12 and above the following results were obtained.

Sensitivity	**81.71%**
Specificity	**100%**
Positive Predictive Value	**100%**
Negative Predictive Value	**75%**
Diagnostic Accuracy	**88.19%**

When the cut off score was calculated at a score of 13 and above the following results were obtained.

Sensitivity	**65.85%**
Specificity	**100%**
Positive Predictive Value	**100%**
Negative Predictive Value	**61.64%**
Diagnostic Accuracy	**77.95%**

When the cut off score was calculated at a score of 14 and above the following results were obtained.

Sensitivity	**42.68%**
Specificity	**100%**
Positive Predictive Value	**100%**
Negative Predictive Value	**48.91%**
Diagnostic Accuracy	**62.99%**

When the cut off score was calculated at a score of 15 and above the following results were obtained.

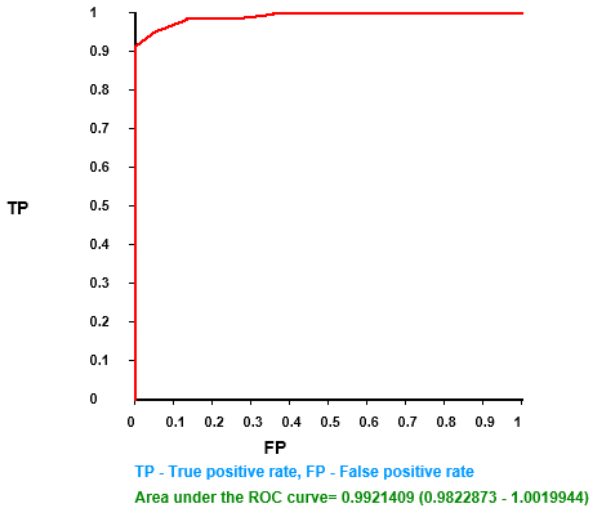
Sensitivity	**18.29%**
Specificity	**100%**
Positive Predictive Value	**100%**
Negative Predictive Value	**40.18%**
Diagnostic Accuracy	**47.24%**

The optimum cut off is to be fixed with the highest specificity and sensitivity along with the best diagnostic accuracy. From the above mentioned tables when the cut off score is placed at **10** the highest possible blend of sensitivity and specificity occurs i.e. **95.12%** and **95.56%** respectively. It is to be noted that the PPV and NPV for the scoring system is **97.50%** and **91.49%.** The diagnostic accuracy of the scoring system is also the maximum at this cut off score i.e. **95.28%.**

Hence according to the combined predictor scoring system when the patient's score **crosses 10 then he/she should be operated for acute appendicitis** and the diagnostic yield is maximum. When the score is less than 10 then he/she should be observed or investigated for alternative diagnosis.

Receiver Operator Characteristic (ROC) Curve for New Combined predictor Scoring system:

The receiver operator characteristic (ROC) curve was plotted for the New combined predictor score and the area under the curve was calculated. The area under the curve is **0.99**.

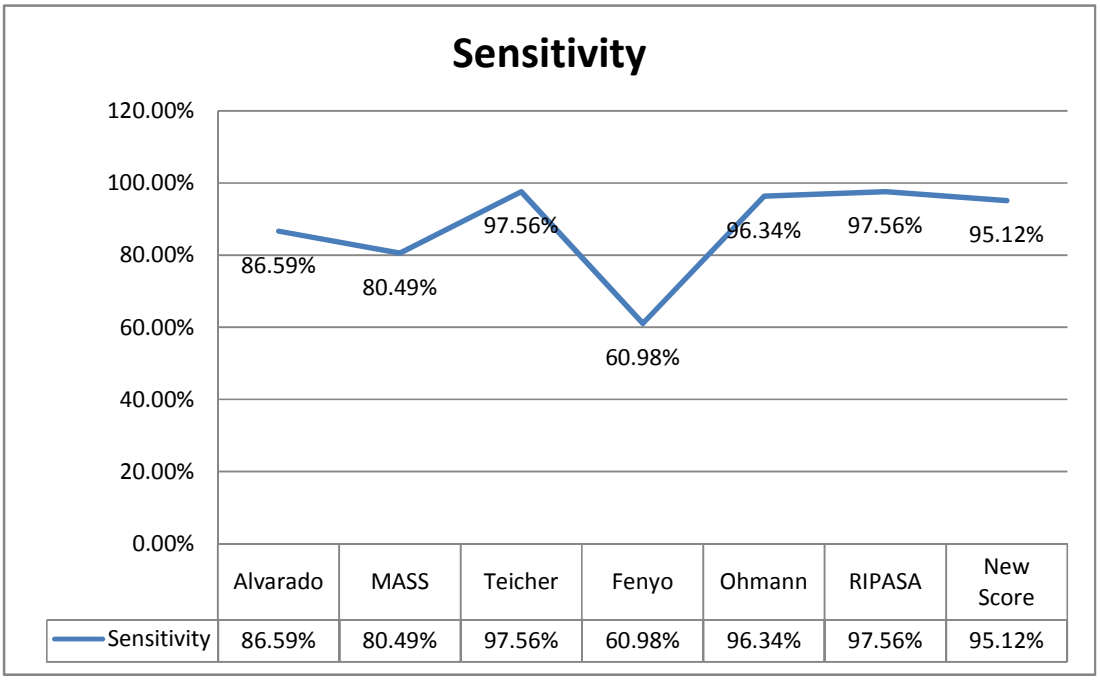


ROC curve for the new combined predictor score

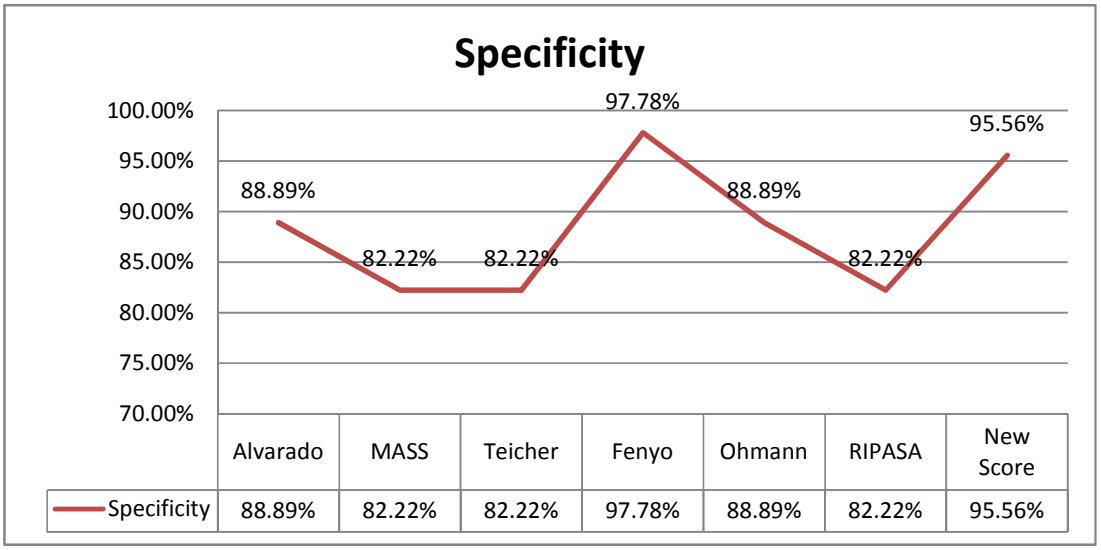
Comparison of results

The various scoring systems analysed were compared among themselves and along with the combined predictor score formulated. The results are tabulated below.

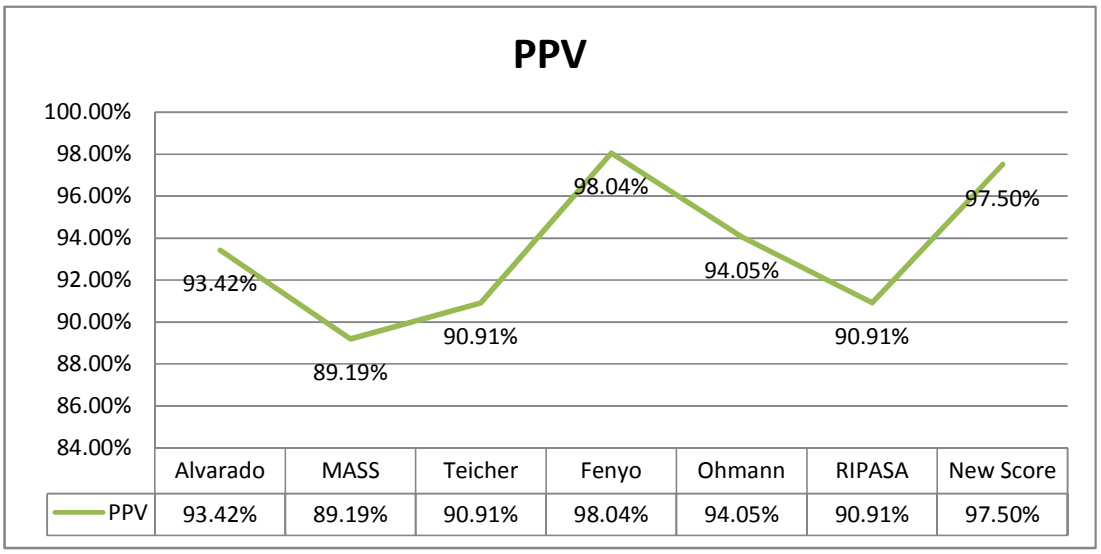
Parameter	Alvarado	MASS	Teicher	Fenyo	Ohmann	RIPASA	Combined Predictor Score
Sensitivity	86.59%	80.49%	97.56%	60.98%	96.34%	97.56%	**95.12%**
Specificity	88.89%	82.22%	82.22%	97.78%	88.89%	82.22%	**95.56%**
PPV	93.42%	89.19%	90.91%	98.04%	94.05%	90.91%	**97.50%**
NPV	78.43%	69.81%	94.87%	57.89%	93.02%	94.87%	**91.49%**
Diagnostic accuracy	87.40%	81.10%	92.13%	74.02%	93.70%	92.13%	**95.28%**



From the above mentioned figure, sensitivity is highest for **Teicher's** score and **RIPASA** score. The sensitivity for the combined predictor score is 95.12% and is comparable with them and higher than others.

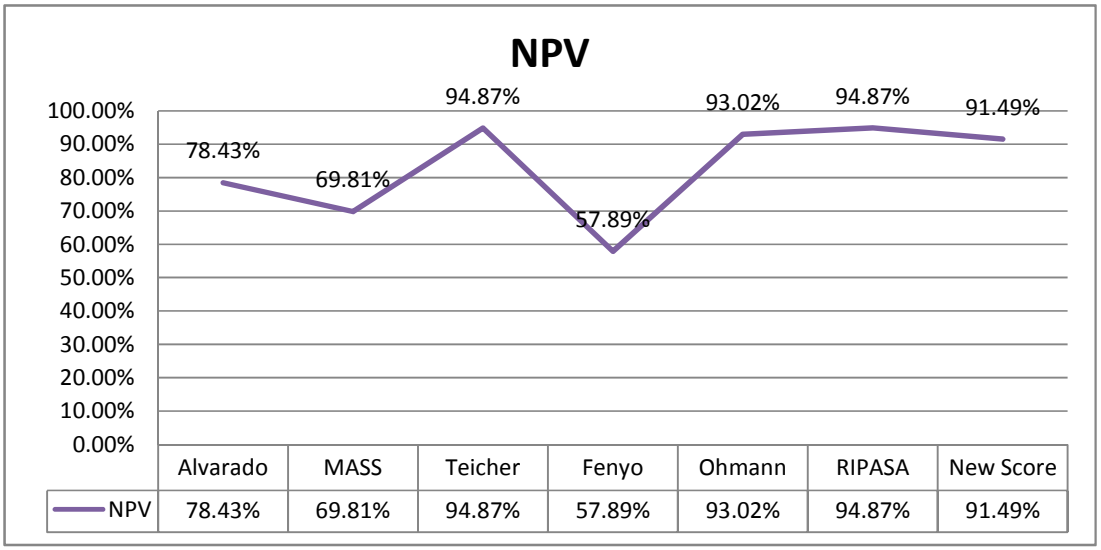


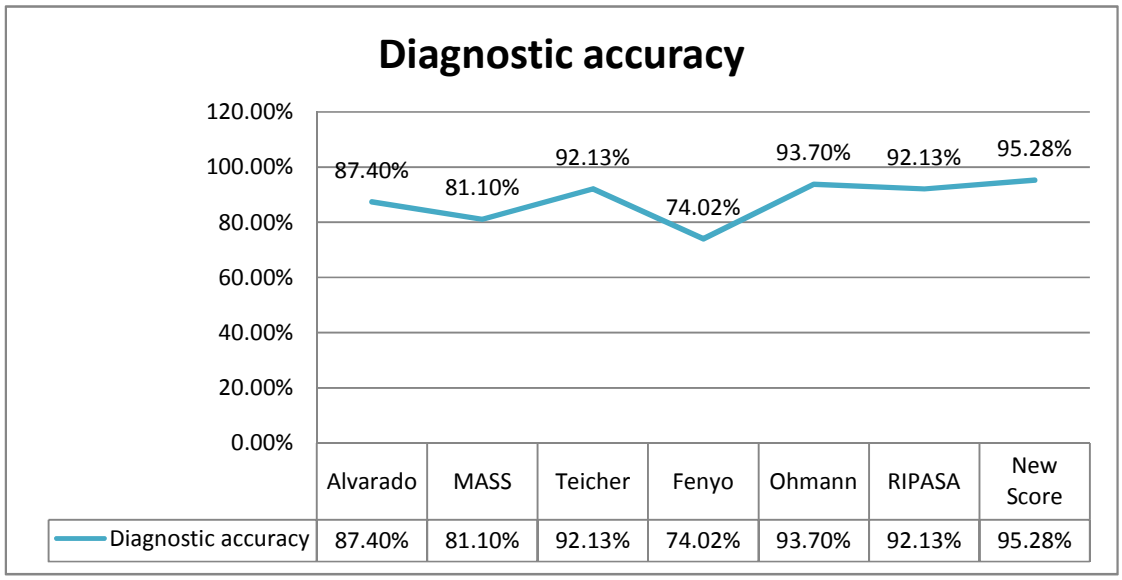
From the above mentioned figure, specificity is highest for **Fenyo's** score. The specificity for the combined predictor score is 95.56% and other scoring systems have a lower specificity when compared with it.



From the above mentioned figure, **Fenyo's** score has the best positive predictive value and the PPV for the combined predictor score is 97.50% and is comparable with it.

From the figure below, **Teicher's** and **RIPASA** score has the best negative predictive value, Fenyo's score has the least NPV and the NPV for the combined predictor score is 91.49%.





From the above mentioned figure, the **combined predictor score** has got the best diagnostic accuracy when compared with other scoring systems. Among other scores **Ohmann's** score has the best diagnostic accuracy.

Conclusion:

From this study it is very well understood that each scoring system is specific to its own population. In our population (patients presenting at Coimbatore medical college hospital) all the scoring systems have been compared and it is found that RIPASA scoring system and Teicher's score have got the best sensitivity and negative predictive value while Fenyo's scoring system is more specific and has the highest positive predictive value. Ohmann's scoring system has the best diagnostic accuracy among other scoring systems.

The combined predictor score which has been developed from various possible predictors has got a sensitivity, specificity, positive predictive value, negative predictive value comparable with the highest value in each category. This score has the best diagnostic accuracy when compared to other scoring systems in our population.

This scoring system is formed in such a manner that it can be used in secondary care hospitals where there is minimal facilities for investigations.

Its simplicity makes it easy to remember.

Limitations of the study

Since the scoring system has been calculated in a retrospective manner to check its application in practice, the same has got be done in more number of cases in a prospective manner.

The study population is taken only from the patients presenting to Coimbatore medical college hospital, to check the validity of the score it should be applied and checked in other varied population.

The accuracy of imaging modalities in predicting the nature of the disease can be incorporated in formulation of new protocols of management.

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Appendix I

Performa for "A Study On Clinical and Laboratory Parameters in Diagnosing Patients with Acute Appendicitis"

Place : S1 unit, CMCH S.no:

Name:

Age: Sex:

IP no:

DOA:

DOS:

History of Presenting illness

Symptom	+ / -	Duration
RIF pain		
Fever		
Nausea		
Vomitting		
Anorexia		
Dysuria		

Clinical examination

Physical finding	+ / -
RIF tenderness	
Guarding	
Rigidity	
Rebound Tenderness	
Rousing's sign	
Elevated temperature	

Laboratory parameters

Total WBC count	
Differential count	
Sr. Bilirubin	
CRP	
ESR	
Urine analysis	

Intra operative findings

Macroscopic appearance

Pus C/S

HPE report:

Post operative period:

Calculated Scores:

Scoring System	Score	Inference
Alvarado		
Modified Alvarado		
IRA Teicher		
Fenyo's		
Ohmann's		
RIPASA		

Appendix II

Master Chart

Name	IP no	Age	Sex	Duration <2 Days	Location	Migration to RIF	Anorexia	Vomiting	Fever	Dysuria	PR T*	RIF T*	Guarding	Rigidity	R T	Rousing	Temp	TC >10000	DC N > 75%	CRP >10 mg	Bilirubin <2 mg	Urine analy	ESR > 15 mm	C/S	HPE
Alphones	21984	-	M	-	other	-	+	+	-	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Amaravathy	15829	-	F	+	other	-	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	+	-	-	mass
Amarullah	78973	+	M	+	Peri	+	+	+	+	-	-	+	+	+	-	-	-	+	+	-	+	-	-	-	In
Amirthaveni	7855	-	F	-	Peri	+	+	-	-	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Anandham	43461	+	M	-	other	-	+	+	-	-	-	+	-	-	-	-	-	-	-	+	+	+	+	-	N
Anitha	70240	+	F	+	Peri	+	+	+	+	-	+	+	+	+	-	+	+	-	+	+	+	-	+	-	In
Antony	60605	-	M	+	Peri	-	+	+	+	+	+	+	-	+	-	-	-	-	-	+	+	-	+	-	MD
Arshath	35237	+	M	+	Peri	+	+	+	+	-	-	+	-	+	-	+	+	+	+	+	+	-	+	-	In
Arumugam	35566	+	M	-	Peri	+	+	+	+	-	-	+	-	-	-	-	-	+	-	+	+	-	+	-	N
Arun	51661	+	M	-	Peri	+	+	+	+	-	+	+	+	-	+	+	-	+	+	+	+	-	+	-	In
Ashok Kumar	8133	+	M	+	Peri	+	+	+	+	-	-	+	-	-	+	-	+	+	+	+	+	-	+	-	In
Babu	24271	+	M	-	other	+	-	+	-	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Babu	54022	+	M	+	Peri	+	+	-	+	-	-	+	+	+	-	+	-	-	+	-	+	-	-	-	In
Badrinarayanan	42812	-	M	+	other	-	-	-	+	-	-	+	+	+	-	-	+	+	+	+	+	-	+	-	LA
Balasarathy	36547	+	M	+	Peri	+	+	+	-	+	-	+	-	-	-	-	-	-	-	+	+	+	+	-	N
Banumathi	75460	+	F	-	Peri	+	-	+	-	+	-	+	-	-	-	-	-	-	-	-	+	-	-	-	N
Chellamuthu	16559	-	M	-	Peri	+	-	+	+	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Daisy	59894	+	F	+	Peri	+	-	+	+	-	-	+	+	+	-	+	+	+	+	+	+	-	+	-	In
Deephalakshi	51166	-	F	-	other	-	+	-	-	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Devasigamani	75510	-	F	-	Peri	+	-	-	-	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Dhanalakshmi	5728	-	F	+	Peri	+	+	+	-	-	-	+	-	-	+	+	+	-	-	+	+	-	+	-	In

Dhivya	48817	+	F	+	Peri	+	+	+	+	-	+	+	+	+	-	+	+	+	+	+	+	-	+	-	In
Dinesh Kumar	26476	+	M	+	Peri	+	+	-	+	-	-	+	+	+	-	-	-	+	+	+	+	-	+	-	In
Divya Barathi	66322	+	F	+	Peri	+	+	+	+	-	-	+	+	+	+	-	+	+	+	+	+	-	+	-	In
Durai	51233	+	M	+	Peri	+	+	+	+	-	-	+	-	-	-	+	+	+	+	+	+	+	+	-	In
Elangiyam	68984	+	M	+	Peri	+	+	+	+	-	-	+	+	-	+	+	-	+	+	+	+	-	+	-	In
Ganesan	11264	+	M	+	Peri	+	+	+	+	-	-	+	+	-	+	+	+	+	+	+	+	-	+	-	In
Gayathri	68725	+	M	-	Peri	-	-	+	-	+	-	+	-	-	-	-	+	-	-	-	+	+	-	-	N
Geetha	58546	+	F	+	Peri	+	+	-	+	-	-	+	+	-	+	+	+	-	-	+	+	-	+	+	P
Gency	27555	+	F	-	Peri	+	+	+	+	-	-	+	-	-	-	-	-	-	-	+	+	-	+	-	N
Girivasan	51291	+	M	-	Peri	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	-	-	+	+	G
Hamsaveni	48960	+	F	-	other	-	+	+	-	+	-	+	-	-	-	-	-	+	-	-	+	+	-	-	N
Hemanth	36271	+	M	-	Peri	+	+	+	+	-	-	+	-	-	-	-	-	+	-	-	+	-	-	-	In
Jagadeeshkumar	47277	+	M	+	Peri	+	+	+	+	-	+	+	+	+	-	+	+	+	+	+	+	-	+	-	In
Jayashree	6244	-	F	+	Peri	+	-	+	+	-	-	+	+	+	-	+	-	+	+	+	+	-	+	-	In
Jessla	5646	+	F	+	other	+	+	+	+	-	-	+	+	-	+	+	-	+	+	+	+	-	+	-	In
Jeyaselvi	48712	-	F	+	other	-	+	-	-	-	-	+	+	-	+	+	-	-	-	+	+	-	+	-	In
Jothi	24596	+	F	+	Peri	+	+	-	+	-	-	+	+	-	+	+	+	+	+	+	+	-	+	+	P
Kamachinathan	40652	-	M	-	Peri	+	+	+	+	-	-	+	-	-	-	-	-	+	+	+	+	+	+	-	N
Kannan	67731	-	M	-	Peri	+	+	-	-	+	-	+	-	-	-	-	-	-	-	-	+	-	-	-	N
Karan	70241	+	M	+	Peri	+	+	+	+	-	-	+	+	+	-	-	+	+	+	+	+	-	+	+	P
Karthick	9640	+	M	+	other	+	-	+	+	-	-	+	+	+	-	+	+	-	+	+	+	-	+	+	P
Karthick	22043	+	M	+	other	+	+	-	+	-	-	+	+	+	-	+	+	+	+	+	+	+	+	-	In
Karthigadhur	46959	+	M	+	Peri	-	+	+	+	-	-	+	+	-	+	+	-	+	+	+	+	-	+	-	In
Karthikayini	71586	+	F	-	Peri	+	+	+	-	+	-	+	-	-	-	-	-	+	-	-	+	-	-	-	N
Karuppamy	1739	+	M	+	Peri	+	+	+	+	-	-	+	+	-	+	+	+	+	+	+	+	-	+	-	In
Kathiravan	44567	+	M	-	Peri	+	+	+	+	-	-	+	-	-	-	-	-	+	+	+	+	+	+	-	N
Kathreena	63613	+	F	-	Peri	+	+	+	+	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Kavitha	43403	+	F	-	Peri	+	+	+	-	-	-	+	-	-	-	-	-	+	-	+	+	-	+	-	N

Kaviyarasan	40748	+	M	+	Peri	+	+	-	+	-	-	+	-	-	+	+	+	+	+	+	+	+	+	+	P
Krithika	59879	+	F	+	Peri	+	-	+	+	-	-	+	+	-	+	+	-	-	+	+	+	-	+	-	In
Loganayaki	60111	+	F	+	Peri	+	+	+	+	-	-	+	+	-	+	+	+	-	-	+	+	-	+	-	In
Madhura Muthu	4070	+	M	+	other	+	+	+	+	-	-	+	+	-	+	+	-	+	+	+	+	-	+	-	In
Maheswari	41001	+	F	-	Peri	+	-	+	+	+	+	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Manikandan	36260	+	M	-	other	-	-	-	+	-	+	+	-	+	-	-	-	+	+	+	+	-	+	-	LA
Manoj	43457	+	M	+	Peri	+	+	+	+	-	-	+	+	-	+	-	+	-	-	+	+	-	+	-	In
Manomani	47471	+	M	+	other	+	+	-	+	+	-	+	-	-	+	+	-	+	+	-	+	+	-	-	N
Margerite	1124	+	F	+	Peri	+	+	+	+	-	-	+	+	-	+	+	+	+	+	+	+	-	+	-	In
Mohan	54015	-	M	+	Peri	+	+	-	+	-	-	+	+	+	-	-	+	+	+	+	+	-	+	-	In
Mohan	71989	+	M	-	Peri	+	+	+	-	+	+	+	-	-	-	-	-	-	-	-	+	-	-	-	N
Nandha Kumar	55710	+	M	+	Peri	+	+	+	+	-	-	+	+	-	+	+	-	+	+	+	+	-	+	-	In
Nandhini	17185	+	F	+	Peri	+	+	+	-	-	-	+	+	-	+	+	-	+	+	+	-	-	+	+	P
Natai Ali	26303	+	M	+	Peri	+	+	+	+	-	-	+	+	-	+	+	+	+	+	+	+	-	+	-	In
Nazima	58513	+	F	-	Peri	+	+	+	+	-	-	+	+	-	+	+	-	+	+	+	+	-	+	-	In
Nishanth	35631	+	M	-	Peri	+	+	+	+	-	-	+	-	-	+	-	-	+	+	+	+	+	+	-	N
Nithya	21809	+	F	+	other	+	+	+	+	-	-	+	+	-	+	+	+	+	+	+	-	-	+	+	P
Nithyanandham	50060	+	M	+	Peri	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+	+	-	+	-	In
Padrammal	48626	+	F	+	Peri	+	-	+	+	-	-	+	+	-	+	+	-	+	+	+	+	-	+	-	In
Palanisamy	47445	+	M	+	Peri	+	+	+	+	-	-	+	-	-	+	+	+	+	+	+	+	-	+	-	In
Parveen	7887	+	M	+	Peri	+	+	+	+	-	-	+	+	-	+	+	+	+	-	+	+	-	+	-	In
Paulraj	54056	+	M	+	Peri	+	+	-	+	-	-	+	+	-	+	-	+	-	-	-	+	-	-	-	In
Ponnan	7068	+	M	+	Peri	+	-	+	+	-	-	+	+	-	+	-	+	+	+	+	+	-	+	-	In
Prakash	67686	+	M	-	Peri	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	G
Prema	69034	+	F	-	other	-	-	+	-	+	-	+	-	-	-	-	-	-	-	-	+	-	-	-	N
Pushpa	66277	+	F	+	Peri	+	+	+	+	-	-	+	+	-	+	-	+	+	-	+	+	+	+	-	In
Pushpalatha	48678	+	F	+	other	+	+	-	-	-	-	+	+	-	+	+	+	-	-	-	+	-	-	-	In
Radha	42144	+	F	+	Peri	+	+	+	+	-	+	+	-	-	-	+	+	+	+	+	+	-	+	-	In

Ragunathan	63699	+	M	-	Peri	+	-	+	-	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Rajan	21882	+	M	-	Peri	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Ramalakshmi	51295	+	F	+	Peri	+	+	+	+	-	-	+	+	-	+	+	+	+	+	+	+	-	+	-	In
Ramasamy	45605	-	M	-	Peri	+	-	+	+	-	+	+	+	-	+	+	-	-	-	+	-	-	+	+	P
Ramesh	15305	+	M	+	Peri	+	+	+	+	-	+	+	+	-	+	+	+	+	+	+	+	-	+	-	In
Rangal	22985	-	F	-	other	-	-	+	+	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Rathna	12958	+	F	+	Peri	+	+	+	-	-	-	+	+	+	-	+	+	-	-	+	+	-	+	-	In
Rohit	75594	+	M	+	other	-	+	+	-	-	-	+	+	-	+	+	+	+	+	-	+	-	-	-	In
Ruban	52958	+	M	-	Peri	-	-	+	+	+	+	+	-	-	-	-	-	-	-	-	+	-	-	-	Mu
Sakthivel	34174	+	M	-	Peri	+	-	+	-	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Sakthivel	63170	+	M	+	Peri	+	+	+	-	-	-	+	+	-	+	-	+	-	-	+	-	-	+	-	In
Sakul Ahmed	8655	+	M	-	Peri	+	+	-	-	-	-	+	+	+	-	+	-	+	+	-	-	-	-	-	P
Samban	8548	+	M	+	Peri	+	+	+	+	-	-	+	+	-	+	-	+	+	+	+	+	-	+	-	In
Sandhiya	44758	+	F	-	Peri	+	+	+	-	+	-	+	-	-	-	-	-	-	-	+	+	+	+	-	N
Sangeetha	11129	+	F	-	Peri	+	+	+	-	+	-	+	-	-	-	-	-	+	+	-	+	-	-	-	N
Saranya	65115	+	F	-	Peri	+	-	-	-	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Sarasathi	22933	+	F	-	other	+	+	+	+	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Saraswathy	58561	-	F	-	Peri	+	+	+	-	-	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Saroja Devi	41109	+	F	+	Peri	+	+	+	+	-	-	+	+	-	+	-	-	+	+	+	+	-	+	-	In
Sarojini	47518	+	F	-	Peri	+	+	-	+	-	-	+	+	-	+	+	+	+	+	+	+	-	+	-	In
Sathya Selan	50256	+	M	+	Peri	+	+	+	+	-	-	+	+	-	+	+	+	+	+	+	+	-	+	-	P
Shadick Ali	8007	+	M	+	Peri	+	+	+	+	-	-	+	+	-	+	+	-	+	+	-	+	-	-	-	In
Shanjai	66269	+	M	+	Peri	-	+	+	+	-	-	+	+	+	-	+	+	+	-	-	+	-	-	-	In
Shanmugam	54508	-	M	+	Peri	+	+	+	+	-	-	+	-	-	+	+	+	+	+	+	+	-	+	-	In
Sharif	52965	+	M	-	Peri	+	-	+	-	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Shiva	32836	+	M	+	Peri	+	-	-	+	-	-	+	-	-	+	-	+	+	+	+	+	-	+	-	In
Siva	23612	+	M	-	Peri	+	+	+	-	+	-	+	-	-	-	-	-	-	-	-	+	-	-	-	N
Soundarya	38257	+	F	+	Peri	+	+	+	+	-	-	+	+	-	+	+	-	+	+	+	+	-	+	-	In
Soundharya	46052	+	F	-	Peri	+	+	+	+	-	-	+	+	-	+	-	+	+	+	+	+	-	+	-	In

Sowdammal	67910	-	F	+	Peri	+	+	+	+	-	-	+	+	-	+	+	+	+	+	+	+	-	+	-	In
Subramani	22006	+	M	+	other	+	+	+	+	-	-	+	+	-	+	+	+	+	+	+	+	+	+	-	In
Sumaiya	25319	+	F	+	Peri	+	+	+	+	-	-	+	+	+	-	-	-	-	-	+	+	-	+	-	In
Suman	11388	+	M	+	Peri	+	+	-	+	-	+	+	-	-	+	-	-	+	+	+	+	-	+	-	In
Sundara Raj	20505	+	M	+	Peri	+	+	+	+	-	-	+	+	+	-	+	+	+	+	+	+	-	+	-	In
Surthi	36260	+	F	-	Peri	+	+	+	+	-	-	+	-	-	-	-	-	-	-	+	+	+	+	-	N
Udhayakumar	32025	+	M	-	other	+	+	+	+	+	-	+	+	-	+	+	+	+	+	-	+	-	-	-	In
Vadivel	54170	+	M	+	Peri	+	+	+	+	-	-	+	+	+	-	+	-	+	+	+	+	-	+	-	In
Vanaraj	24902	+	M	+	Peri	+	+	-	+	-	-	+	-	-	+	+	+	+	+	+	-	-	+	+	P
Vanitha	60586	+	F	-	other	-	-	+	+	-	-	+	-	-	-	-	-	+	+	+	+	-	+	-	N
Vasanthi	51568	+	F	+	Peri	-	+	+	+	-	-	+	-	-	-	-	-	+	-	+	+	-	+	-	N
Vasathi	47525	+	F	-	Peri	+	+	+	+	-	-	+	-	-	-	-	-	-	-	+	+	-	+	-	N
Velmurugan	59228	+	M	+	Peri	+	+	+	+	-	-	+	+	+	+	-	-	-	+	+	+	-	+	-	In
Velusamy	39152	-	M	+	other	+	+	+	+	-	-	+	+	-	+	+	+	+	+	+	+	-	+	-	In
Venkatesh	45184	+	M	+	Peri	+	+	+	+	-	-	+	+	-	+	+	+	+	+	+	+	-	+	-	P
Vetri	71693	+	M	-	Peri	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	-	-	+	+	G
Vigneswaran	74327	+	M	+	Peri	+	+	+	+	-	-	+	+	+	-	+	+	+	+	-	+	-	-	-	In
Vijay	41077	+	M	+	other	+	+	+	+	-	-	+	+	-	+	+	-	-	-	+	+	-	+	-	In
Vikas	206	-	M	-	Peri	+	-	-	+	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	N
Visalakshi	61319	+	F	+	Peri	+	+	+	+	-	-	+	+	+	-	+	+	+	+	+	+	-	+	-	In
Yesudas	25379	+	M	-	Peri	+	+	-	+	-	-	+	+	-	+	+	+	+	+	-	+	-	-	-	In

Key for Master chart

T* - Tenderness

G- Gangrenous

Peri - Periumbilical

N – Normal

Mu – Mucocele

RT – Rebound Tenderness

In – Inflamed

LA – Mesentric lymphadenitis

P – Perforated

MD – Meckel's Diverticulum

Appendix III

Master chart for scoring system

Name	IP no	HPE	Alavarado	MASS	Triecher	Ohmanns	Fenyo's	RIPASA	Combined predictor score
Alphones	21984	N	4	4	-7	5.5	-60	5.5	2
Amaravathy	15829	mass	4	4	-9	5.5	-64	5.5	3
Amarullah	78973	In	8	7	7	13.5	21	10.5	11
Amirthaveni	7855	N	4	4	-10	8.5	-79	4	2
Anandham	43461	N	4	4	-8	8	-60	6	6
Anitha	70240	In	8	6	-4	12	-14	12	14
Antony	60605	MD	4	4	-6	7.5	-22	6.5	7
Arshath	35237	In	9	8	1	12.5	21	11.5	14
Arumugam	35566	N	6	7	-3	12.5	-20	8	9
Arun	51661	In	9	8	0	16	10	13	13
Ashok kumar	8133	In	10	9	1	15	7	10.5	13
Babu	24271	N	4	4	-11	7	-44	5.5	3
Babu	54022	In	6	4	2	12	7	10.5	10
Badrinarayanan	42812	LA	6	5	11	10	-17	9	10
Balasarathy	36547	N	5	5	-7	9	-32	6.5	7
Banumathi	75460	N	4	4	-14	9	-67	5.5	4
Chellamuthu	16559	N	4	4	-7	8.5	-37	4.5	2
Daisy	59894	In	8	7	4	13.5	3	12	14
Deephalakshi	51166	N	3	3	-10	5.5	-95	4	1
Devasigamani	75510	N	3	3	-10	8.5	-79	3	1
Dhanalakshmi	5728	In	7	7	-3	13	-25	10.5	11
Dhivya	48817	In	9	8	1	13.5	3	13	15
Dinesh kumar	26476	In	7	6	7	13.5	2	9.5	12
Divya barathi	66322	In	10	9	4	16	3	12	15
Durai	51233	In	9	8	1	12.5	17	10.5	12
Elangiyam	68984	In	9	8	7	16	22	13.5	14
Ganesan	11264	In	10	9	7	16	22	14.5	15
Gayathri	68725	N	4	4	-11	8	-60	5.5	3
Geetha	58546	P	6	6	-1	14.5	-30	12	12
Gency	27555	N	5	5	-11	11	-60	6.5	8
Girivasan	51291	G	10	9	0	16	37	13	14
Hamsaveni	48960	N	5	6	-9	7.5	-66	6.5	4
Hemanth	36271	In	6	7	-3	12.5	-20	7	7
Jagadeeshkumar	47277	In	9	8	4	13.5	36	13.5	15
Jayashree	6244	In	7	6	8	13	3	10.5	12
Jessla	5646	In	9	8	4	14	-1	13.5	14
Jeyaselvi	48712	In	4	4	3	11	-53	10.5	9

Jothi	24596	P	9	8	4	16	-13	13	14
Kamachinathan	40652	N	8	7	1	12	-20	6.5	8
Kannan	67731	N	4	4	-7	8.5	-56	5.5	3
Karan	70241	P	9	8	7	13.5	11	11.5	14
Karthick	9640	P	7	5	2	10	9	12	13
Karthick	22043	In	8	7	7	11.5	17	12	13
Karthigadhur	46959	In	8	7	7	15	6	13	13
Karthikayini	71586	N	6	7	-9	10.5	-50	7.5	6
Karuppamy	1739	In	10	9	7	16	25	14.5	15
Kathiravan	44567	N	8	7	-3	12.5	-20	7	9
Kathreena	63613	N	5	5	-14	9	-60	5.5	4
Kavitha	43403	N	6	7	-6	12.5	-50	7.5	9
Kaviyarasan	40748	P	9	8	1	15	10	10.5	12
Krithika	59879	In	7	5	-1	14.5	-18	11	12
Loganayaki	60111	In	7	7	-1	14.5	-18	13	13
Madhura muthu	4070	In	9	8	7	14	25	14	14
Maheswari	41001	N	4	4	-17	9	-60	4.5	3
Manikandan	36260	LA	5	4	-3	9.5	-17	5.5	8
Manoj	43457	In	7	7	2	14.5	-10	11.5	12
Manomani	47471	N	8	7	-2	11	10	10	8
Margerite	1124	In	10	9	4	16	-1	14	15
Mohan	54015	In	5	5	-14	9	-44	7	5
Mohan	71989	N	8	7	11	13	9	10	12
Nandha kumar	55710	In	9	8	7	16	22	13.5	14
Nandhini	17185	P	9	8	4	16	-8	13	14
Natai ali	26303	In	10	9	7	16	22	14.5	15
Nazima	58513	In	9	8	0	16	-13	12.5	13
Nishanth	35631	N	9	8	-3	15	-5	8	10
Nithya	21809	P	10	9	4	14	-1	14.5	15
Nithyanandham	50060	In	10	9	4	14	22	14.5	14
Padrammal	48626	In	8	7	4	16	-1	12	13
Palanisamy	47445	In	10	9	1	15	22	12.5	14
Parveen	7887	In	8	9	7	16	22	14.5	14
Paulraj	54056	In	6	6	2	14.5	-19	10.5	9
Ponnan	7068	In	9	8	7	16	7	11.5	13
Prakash	67686	G	10	9	-3	14	37	13	13
Prema	69034	N	3	3	-14	6	-83	5.5	3
Pushpa	66277	In	8	9	4	16	-13	11	12
Pushpalatha	48678	In	6	6	-1	12.5	-37	12.5	10
Radha	42144	In	9	8	-5	12.5	-16	11	13
Ragunathan	63699	N	4	4	-11	9	-44	5	3
Rajan	21882	N	3	3	-8	10	-60	4.5	3
Ramalakshmi	51295	In	10	9	4	16	-11	14	15
Ramasamy	45605	P	5	5	-1	14	-7	10.5	9
Ramesh	15305	In	10	9	4	16	22	14.5	15
Rangal	22985	N	3	3	-10	5.5	-76	4	1

Rathna	12958	In	6	6	-1	12	-21	12	13
Rohit	75594	In	9	8	7	13	-1	14.5	12
Ruban	52958	Mu	3	3	-14	8	-53	6	3
Sakthivel	34174	N	4	4	-11	9	-44	5	3
Sakthivel	63170	In	7	7	2	14.5	8	11.5	12
Sakul ahmed	8655	P	7	6	3	13.5	-5	11	10
Samban	8548	In	10	9	7	16	7	12.5	14
Sandhiya	44758	N	5	5	-14	9	-67	5.5	6
Sangeetha	11129	N	8	7	-9	10.5	-50	7.5	7
Saranya	65115	N	3	3	-14	9	-79	3.5	2
Sarasathi	22933	N	5	5	-14	7	-60	6	4
Saraswathy	58561	N	5	5	-7	10.5	-67	5	4
Saroja devi	41109	In	9	8	4	16	-16	11	13
Sarojini	47518	In	9	8	0	16	-25	12.5	13
Sathya selan	50256	P	10	9	7	16	22	14.5	15
Shadick ali	8007	In	9	8	7	16	22	13.5	12
Shanjai	66269	In	6	7	7	12.5	20	13	11
Shanmugam	54508	In	10	9	5	14.5	22	12	13
Sharif	52965	N	4	4	-11	9	-44	5	3
Shiva	32836	In	8	7	1	15	-5	8.5	11
Siva	23612	N	5	5	-11	9	-44	7	5
Soundarya	38257	In	9	8	4	16	2	13	14
Soundharya	46052	In	10	9	0	16	-28	11.5	13
Sowdammal	67910	In	10	9	8	15.5	-1	13.5	14
Subramani	22006	In	10	9	7	14	22	14	14
Sumaiya	25319	In	5	5	-1	12	-29	7	11
Suman	11388	In	8	7	-2	15	-5	8.5	11
Sundara raj	20505	In	9	8	7	13.5	26	13.5	15
Surthi	36260	N	5	5	-11	11	-60	5.5	7
Udhayakumar	32025	In	10	9	0	12	10	14.5	11
Vadivel	54170	In	8	7	7	13.5	36	12.5	14
Vanaraj	24902	P	9	8	1	15	13	11.5	13
Vanitha	60586	N	6	5	-6	9.5	-59	6.5	8
Vasanthi	51568	N	5	6	-2	11.5	-47	7.5	9
Vasathi	47525	N	5	5	-11	11	-60	6.5	8
Velmurugan	59228	In	8	6	2	14.5	9	10.5	13
Velusamy	39152	In	10	9	11	13.5	22	14.5	14
Venkatesh	45184	P	10	9	7	16	22	14.5	15
Vetri	71693	G	10	9	0	16	37	14	15
Vigneswaran	74327	In	9	8	7	13.5	26	13.5	13
Vijay	41077	In	6	6	2	12.5	5	13	12
Vikas	206	N	3	3	-7	8.5	-49	3.5	1
Visalakshi	61319	In	9	8	4	13.5	3	13	15
Yesudas	25379	In	9	8	3	16	-2	13	11